PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : G01S 5/14, 5/00 | A1

(11) International Publication Number: WO 00/14567

(43) International Publication Date: 16 March 2000 (16.03.00)

(21) International Application Number: PCT/US99/20280

(22) International Filing Date: 3 September 1999 (03.09.99)

(30) Priority Data:
09/150,074 9 September 1998 (09.09.98) US

(71) Applicant: QUALCOMM INCORPORATED [US/US]; 5775 Morehouse Drive, San Diego, CA 92121-1714 (US).

(72) Inventors: KANG, Inyup; Apartment 326, 5385 Toscana Way, San Diego, CA 92126 (US). SIH, Gilbert, C.; 7804 Pipit Place, San Diego, CA 92129 (US). ZOU, Qiuzhen; 11507 Westview Parkway, San Diego, CA 92126 (US).

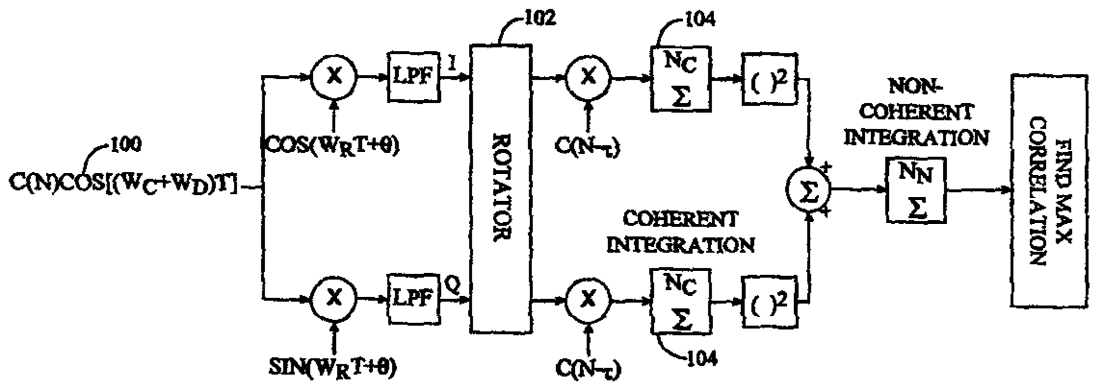
(74) Agents: MILLER, Russell, B. et al.; Qualcomm Incorporated, 5775 Morehouse Drive, San Diego, CA 92121-1714 (US).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published

With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: RECEIVER FOR PERFORMING POSITION LOCATION WITH EFFICIENT ROTATOR



(57) Abstract

The present invention is a novel and improved method and apparatus for performing position location in wireless communications system. One embodiment of the invention comprises a method for performing position location comprising the steps of receiving signal samples, generating a coarse acquisition sequence, rotating said coarse acquisition sequence yielding a rotated coarse acquisition sequence, and applying said rotated coarse acquisition sequence to said signal samples at a set of time offsets yielding correlated output data.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania
AM	Armenia
AT	Austria
AU	Australia
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CU	Cuba
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GH	Ghana
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IL	Israel
IS	Iceland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgyzstan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakstan
LC	Saint Lucia
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LS	Lesotho
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
MK	The former Yugoslav Republic of Macedonia
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam
YU	Yugoslavia
ZW	Zimbabwe

RECEIVER FOR PERFORMING POSITION LOCATION WITH EFFICIENT ROTATOR

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates to position location. More particularly, the present invention relates to a novel and improved method and apparatus for performing position location in wireless communications system.

II. Description of the Related Art

Both government regulation and consumer demand have driven the demand for position location functionality in cellular telephones. The global positioning system (GPS) is currently available for performing position location using a GPS receiver in conjunction with a set of earth orbiting satellites. It is therefore desirable to introduce GPS functionality into a cellular telephone.

Cellular telephones, however, are extremely sensitive to cost, weight and power consumption considerations. Thus, simply adding additional circuitry for performing GPS location is an unsatisfactory solution for providing position location functionality in a cellular telephone. Thus, the present invention is directed to providing GPS functionality in a cellular telephone system with a minimum of additional hardware, cost and power consumption.

SUMMARY OF THE INVENTION

The present invention is a novel and improved method and apparatus for performing position location in wireless communications system. One embodiment of the invention comprises a method for performing position location including the steps of receiving signal samples, generating a coarse acquisition sequence, rotating said coarse acquisition sequence yielding a rotated coarse acquisition sequence, and applying said rotated coarse acquisition sequence to said signal samples at a set of time offsets yielding correlated output data.

BRIEF DESCRIPTION OF THE DRAWINGS

The features, objects, and advantages of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

Fig. 1 is a block diagram of the Global Positioning System (GPS) waveform generator;

Fig. 2 is a highly simplified block diagram of a cellular telephone system configured in accordance with the use of present invention;

Fig. 3 is a block diagram of a receiver configured in accordance with one embodiment of the invention;

Fig. 4 is another block diagram of the receiver depicted in Fig. 3;

Fig. 5 is a receiver configured in accordance with an alternative embodiment of the invention;

Fig. 6 is a flow chart of the steps performed during a position location operation;

Fig. 7 is a block diagram of a DSP configured in accordance with one embodiment of the invention;

Fig. 8 is a flow chart illustrating the steps performed during a search performed in accordance with one embodiment of the invention;

Fig. 9 is a time line illustrating the phases over which fine and coarse searches are performed in one embodiment of the invention;

Fig. 10 is a time line of the search process when performed in accordance with one embodiment of the invention;

Fig. 11 is a diagram of search space.

Fig. 12 is a receiver in accordance with another embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A novel and improved method and apparatus for performing position location in wireless communications system is described. The exemplary embodiment is described in the context of the digital cellular telephone system. While use within this context is advantageous, different embodiments of the invention may be incorporated in different environments or configurations. In general, the various systems described herein may be formed using software controlled processors, integrated circuits, or discreet logic, however, implementation in an integrated circuit is preferred. The data, instructions, commands, information, signals, symbols and chips that may be referenced throughout the application are advantageously represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or a combination thereof. Additionally, the blocks shown in each block diagram may represent hardware or method steps.

Fig. 1 is a block diagram of the Global Positioning System (GPS) waveform generator. The circle with a plus sign designates modulo-2 addition. In general, the GPS constellation consists of 24 satellites: 21 space vehicles (SVs) used for navigation and 3 spares. Each SV contains a clock that is synchronized to GPS time by monitoring ground stations. To determine a position and time, a GPS receiver processes the signals received from several satellites. At least 4 satellites must be used to solve for the 4 unknowns (x, y, z, time).

Each SV transmits 2 microwave carriers: the 1575.42 MHz L1 carrier, which carries the signals used for Standard Positioning Service (SPS), and the 1227.60 MHz L2 carrier, which carries signals needed for Precise Positioning Service (PPS). PPS is used by governmental agencies and allows a higher degree of accuracy in positioning.

The L1 carrier is modulated by the Coarse Acquisition (C/A) code, a 1023-chip pseudorandom code transmitted at 1.023 Mcps that is used for civil position location services. (The Coarse Acquisition code should not be confused with the coarse and fine acquisitions described herein, which both involve the use of the C/A codes.) Each satellite has its own C/A code that repeats every 1ms. The P code, which is used for PPS, is a 10.23 MHz code that is 267 days in length. The P code appears on both carriers but is 90 degrees out of phase with the C/A code on the L1 carrier. The 50Hz navigation message, which is exclusive-ORed with both the C/A code and P code before carrier modulation, provides system information such as satellite orbits and clock corrections.

The L1 carrier is modulated by the Coarse Acquisition (C/A) code, a 1023-chip pseudorandom code transmitted at 1.023 Mcps that is used for civil position location services. Each satellite has its own C/A code that repeats every 1ms. The P code, which is used for PPS, is a 10.23 MHz code that is 267 days in length. The P code appears on both carriers but is 90 degrees out of phase with the C/A code on the L1 carrier. The 50Hz navigation message, which is exclusive-ORed with both the C/A code and P code before carrier modulation, provides system information such as satellite orbits and clock corrections.

The L1 carrier is modulated by the Coarse Acquisition (C/A) code, a 1023-chip pseudorandom code transmitted at 1.023 Mcps that is used for civil position location services. Each satellite has its own C/A code that repeats every 1ms. The P code, which is used for PPS, is a 10.23 MHz code that is 267 days in length. The P code appears on both carriers but is 90 degrees out of phase with the C/A code on the L1 carrier. The 50Hz navigation message, which is exclusive-ORed with both the C/A code and P code before carrier modulation, provides system information such as satellite orbits and clock corrections.

Each satellite has a different C/A code that belongs to a family of codes called Gold codes. Gold codes are used because the cross-correlation between them are small. The C/A code is generated using two 10-stage shift registers as shown below in figure 1.4-2. The G1 generator uses the polynomial $1+X^3+X^{10}$, while the G2 generator uses the polynomial $1+X^2+X^3+X^6+X^8+X^9+X^{10}$. The C/A code is generated by exclusive ORing the output of the G1 shift register with 2 bits of the G2 shift register.

Fig. 2 is a highly simplified block diagram of a cellular telephone system configured in accordance with the use of present invention. Mobile telephones **10** are located among base stations **12**, which are coupled to base station controller (BSC) **14**. Mobile switching center MSC **16** connects BSC **14** to the public switch telephone network (PSTN). During operation, some mobile telephones are conducting telephone calls by interfacing with base stations **12** while others are in standby mode.

As described in copending US patent application serial no. 09/040,051 entitled "SYSTEM AND METHOD FOR DETERMINING THE POSITION OF A WIRELESS CDMA TRANCEIVER" assigned to the assignee of the present invention and incorporated herein by reference, position location is facilitated by the transmission of a position request message containing "aiding information" that allows the mobile telephone to quickly acquire the GPS signal. This information includes the ID number of the SV (SV ID), the estimated code phase, the search window size around the estimate code phase, and the estimated frequency Doppler. Using this information, the mobile unit can acquire the GPS signals and determine its location more quickly.

In response to the aiding message, the mobile unit tunes to the GPS frequency and begins correlating the received signal with its locally generated C/A sequences for the SVs indicated by the base station. It uses the aiding information to narrow the search space and compensate for Doppler effects, and obtains pseudo-ranges for each satellite using time correlation. Note that these pseudo-ranges are based on mobile unit time (referenced from the CDMA receiver's combiner system time counter), which is a delayed version of GPS time.

Once this information is calculated, the mobile unit sends the pseudo-ranges for each satellite (preferably to 1/8 chip resolution) and the time the measurements were taken to the base station. The mobile unit then retunes to CDMA to continue the call.

Upon, receipt of the information, the BSC uses the one-way delay estimate to converts the pseudo-ranges from mobile unit time to base station time and computes the estimated position of the mobile unit by solving for the intersection of several spheres.

Another parameter provided by the aiding message is the frequency Doppler or Doppler offset. The Doppler effect manifests as an apparent change in the frequency of a received signal due to a relative velocity between the transmitter and receiver. The effect of the Doppler on the carrier is referred to as frequency Doppler, while the effect on the baseband signal is referred to as code Doppler.

In the GPS case, frequency Doppler changes the received carrier frequency so the effect is the same as demodulating with a carrier offset. Since the base station's GPS receiver is actively tracking the desired satellite, it knows the frequency Doppler due to satellite movement. Moreover, the satellite is so far away from the base station and the mobile unit that the Doppler seen by the mobile unit is effectively the same as the Doppler seen by the base station. In one embodiment of the invention, to correct for the frequency Doppler value, the mobile unit uses a rotator in the receiver. The frequency Doppler ranges from –4500Hz to +4500Hz, and the rate of change is on the order of 1 Hz/s.

The effect of the code Doppler is to change the 1.023Mhz chip rate, which effectively compresses or expands the width of the received C/A code chips. In one embodiment of the invention, the mobile unit correct for code Doppler by multiplying the frequency Doppler by the ratio 1.023/1575.42. The mobile unit can then correct for code Doppler over time by slewing (introducing delay into) the phase of the received IQ samples in 1/16 chip increments as necessary.

Fig. 3 is a block diagram of the receiver portion of a cellular telephone (wireless subscriber unit) configured in accordance with one embodiment of the invention. The received waveform **100** is modeled as the C/A signal c(n) modulated with a carrier at frequency $w_c + w_d$, where w_c is the nominal carrier frequency 1575.42 MHz, and w_d is the Doppler frequency created by satellite movement. The Doppler frequency ranges from 0 when the satellite is directly overhead, to about 4.5kHz in the worst case. The receiver analog section can be modeled as demodulation with a carrier at frequency w_r and random phase θ, followed by low pass filtering.

The resulting baseband signal is passed through an A/D converter (not shown) to produce digital I and Q samples, which are stored so that they may be repeatedly searched. The samples are generated at two times the C/A code chip rate (chipx2) which is a lower resolution than necessary to perform the fine search algorithm, but which allows 18 ms of sample data to be stored in a reasonable amount of memory. In general, it is desirable to perform the searching over something greater than 10ms in order to allow acquisition in most environmental conditions, with 18ms being a preferred integration period. These environmental conditions include being inside or not having a direct view to the satellite.

During operation, the samples are first rotated by rotator **102** to correct for the Doppler frequency offset. The rotated I and Q samples are correlated with various offsets of the satellite's C/A sequence and the resulting products are coherently integrated over Nc chips by integrators **104**. The coherent integration sums are squared and added together to remove the effect of the unknown phase offset θ. To augment the hypothesis test for a particular offset, several coherent intervals are non-coherently combined. This despreading is performed repeatedly at various time offsets to find the time offset of the satellite signal. Rotator **102** removes the frequency Doppler created by satellite movement. It uses the Doppler frequency specified by the base station (preferably quantized to 10Hz intervals) and rotates the I and Q samples to remove the frequency offset.

In one embodiment of the invention, the rotation is continuous only over the coherent integration window. That is, the rotator stops in between coherent integration periods of, for example, 1 ms. Any resulting phase difference is eliminated by the square and sum.

Fig. 4 is another block diagram of a receiver configured in accordance with one embodiment of the invention, where the rotator portion of the receiver is depicted in greater detail.

Fig. 5 is a receiver configured in accordance with an alternative embodiment of the invention. This internal embodiment of the invention takes advantage of the ability to stop the rotator between coherent integration periods by rotating the locally generated C/A sequence instead of the input samples.

As shown, the C/A sequence c(n) are rotated by application to the sinusoids $\sin(W_d n T_C)$ and $\cos(W_d n T_C)$ and then stored. The rotation of the C/A sequence only needs to be done once for each satellite. Thus, rotating the C/A sequence reduces the amount of computation required. It also saves memory in the DSP used to perform this computation in one embodiment of the invention.

Another significant impairment that degrades the performance of the position location algorithm is the frequency error in the mobile units internal clock. It is this frequency error which drives the use of short coherent integration times on the order of 1 ms. It is preferable to perform coherent integration over longer time periods.

In an exemplary configurations, the mobile's free running (internal) local oscillator clock is a 19.68MHz crystal that has a frequency tolerance of +/-5ppm. This can cause large errors on the order of +/- 7500 Hz. This clock is used to generate the carriers used for demodulation of the GPS signals, so the clock error will add to the signal acquisition time. Because the time available to search is very small, error of this magnitude due to the frequency tolerance are not tolerable and must be greatly reduced.

To allow longer coherent integration times, in one embodiment of the invention, the CDMA receiver corrects for local oscillator error by using timing acquired from the CDMA pilot, or any other source of timing information available. This produces a control signal that is used to tune the local oscillator clock to 19.68MHz as closely as possible. The control signal applied to the local oscillator clock is frozen when the RF unit switches from CDMA to GPS.

Even after the correction is performed using the timing information from the bases station (or other source), however, some additional clock error remains. In one embodiment of the invention, the resulting frequency uncertainty after correction is +/- 100Hz. This remaining error still reduces the performance of the receiver, and in general prevents longer coherent integration times. In one embodiment of the invention, the remaining error simply avoided by performing non-coherent integration for duration of more than 1ms which reduces performance.

As also shown in **Fig. 1**, the 50Hz NAV/system data is also modulated onto the L1 carrier. If a data transition (0 to 1 or 1 to 0) occurs between the two halves of a coherent integration window, the resulting coherent integration sum will be zero because the two halves will cancel each other out. This effectively reduces the number of non-coherent accumulations by one in the worst case. Although the data boundaries of all the satellites are synchronized, they do not arrive at the mobile unit simultaneously because of the differences in path delay. This path delay effectively randomizes the received data phase.

In one embodiment of the invention, the problem of different data phases on different signals is to include the data phase in the aiding information sent from the base station to the mobile unit. Since the base station is demodulating the 50Hz data, it knows when the data transitions occur for each satellite. By using knowledge of the one-way delay, the base station can encode the data phase in, for example, 5 bits (per satellite) by indicating which one millisecond interval (out of 20) the data transition occurs on.

If the coherent integration window straddles the 50Hz data boundary the coherent integration is divided into two (2) sections. One section preceding the data boundary and one section following the data boundary. For example, if En1 is the coherent integration sum over the window preceding the data boundary the first half of this window and En2 is the coherent integration sum over the window following the data boundary, the mobile unit then selects the maximum (in magnitude) of (En1 + En2) (in case the data stayed the same) and (En1 – En2) (in case the data changed) to account for the phase change. The mobile unit also has the option of performing non-coherent combining of the two halves over this data window or avoiding this data window completely.

In an alternative embodiment of the invention, the mobile unit attempts to find the data transitions without the aiding information from the base station by comparing the magnitude squared of the sum and difference in 1 ms coherent integration.

In one embodiment of the invention, a firmware-based DSP (Digital Signal Processor) approach is used to perform the GPS processing. The DSP receives I and Q samples at a chipx2 (2.046 MHz) or chipx8 (8.184 MHz) rate, and stores a snapshot of 4-bit I and Q samples in its internal RAM.

In the exemplary embodiment, the DSP generates the C/A sequence, performs rotation to eliminate frequency Doppler, and correlates over the search window provided by the base station for each of the satellites. The DSP performs coherent integration and non-coherent combining and slews an IQ sample decimator as necessary to compensate for code Doppler.

To save computation and memory, the initial search is performed using _ chip resolution and a finer search to obtain 1/8 chip (higher) resolution is performed around the best index (or indexes). System time is maintained by counting hardware-generated 1ms interrupts (derived from local oscillator).

Additionally, in one embodiment of the invention, the fine search is performed by accumulating the chipx8 samples (higher resolution) over the duration of one chip at various chipx8 offsets. The correlation codes are applied to the accumulated values yielding correlation values that vary with the particular chipx8 offset. This allows the code offset to be determined with chipx8 resolution.

Fig. 6 is a flow chart illustrating the steps performed to correct for the local oscillator error during a position location procedure when performed in accordance with one embodiment of the invention. At step **500**, it is determined whether the local oscillator has been corrected recently. If not, then the pilot is acquired from the base station, and error of the local oscillator is determined by comparing to the pilot timing at step **502** and a correction signal generated based on that error.

The flow then leads to step **504**, where the correction signal is frozen at the current value. At step **506**, enters GPS mode and performs the position location using the corrected clock. Once the position location has been performed, the mobile unit leaves GPS mode at step **508**.

Fig. 7 is an illustration of a DSP receiver system configured in accordance with one embodiment of the invention. The DSP performs the entire searching operation with minimal additional hardware. DSP core 308, modem 306, interface unit 300, ROM 302 and Memory (RAM) 304 are coupled via bus 306. Interface unit 300 receives RF samples from an RF unit (not shown) and provides the samples to RAM 304. The RF samples can be stored at coarse resolution or fine resolution. The DSP core 308 processes the samples stored in memory using instruction stored in ROM 302 as well as in memory 304. Memory 304 may have multiple "banks" some of which store samples and some of which store instructions. Modem 700 performs CDMA processing during normal mode.

Fig. 8 is a flow chart of the steps performed during a position location operation. A position location operation begins when the aiding messaging is received, and the RF systems is switched to GPS frequencies at step 600. When the RF is switched to receive GPS, the frequency tracking loop is fixed. The DSP receives aiding information from the phone microprocessor and sorts the satellites by Doppler magnitude.

At step 602, the coarse search data is stored within the DSP RAM. The DSP receives a few hundred microseconds of input data to set an Rx AGC. The DSP records the system time and begins storing an 18ms window (DSP memory limitation) of chipx2 IQ data in its internal RAM. A contiguous window of data is used to mitigate the effects of code Doppler.

Once the data is stored, a coarse search is performed at step 604. The DSP begins the coarse (chipx2 resolution) search. For each satellite, the DSP generates the C/A code, rotates the code based on the frequency Doppler, and correlates over the search window specified by the base station, via repeated application of the C/A code to the stored coarse search data. Satellites are processed over the same 18ms data window and the best chipx2 hypothesis that exceeds a threshold is obtained for each satellite. Although a 2ms coherent integration time (with 9 non-coherent integrations) is used in one embodiment of the invention, longer coherent integration times can be used (for example 18ms), although preferably where additional adjustments are made as described below.

Once the coarse search is performed, a fine search is conducted, at step 606. Before beginning the fine search, the DSP computes the rotated C/A code for each of the satellites. This allows the DSP to process the fine search in real-time. In performing the fine (chipx8 resolution) search, the satellites are processed one at a time over different data.

The DSP first slews the decimator to compensate for code Doppler for the given satellite(s). It also resets the Rx AGC value while waiting for the next 1ms boundary before storing a 1ms coherent integration window of chipx8 samples.

The DSP processes 5 contiguous chipx8 resolution hypotheses on this 1ms coherent integration window, where the center hypothesis is the best hypothesis obtained in the coarse search. After processing the next 1ms window, the results are combined coherently and this 2ms sum is combined non-coherently for all Nn iterations.

This step (starting from slewing the decimator) is repeated on the same data for the next satellite until all the satellites have been processed. If the code Doppler for 2 satellites is similar in magnitude, it may be possible to process both satellites over the same data to reduce the number of required data sets. In the worst case, 8 sets of 2*Nn data windows of 1ms are used for the fine search.

Finally, at step **608**, the results are reported to the microprocessor and the vocoder process is restarted within the DSP so that the call can continue. The DSP reports pseudoranges to the microprocessor, which forwards them to the base station. After the microprocessor redownloads the vocoder program code into the DSP memory, the DSP clears its data memory and restarts the vocoder.

Fig. 9 is a diagram illustrating the fine search performed after the coarse search. After isolating the best chipx2 phase in the coarse search, the DSP performs a fine search around this phase to gain chipx8 resolution.

The 5 phases to compare in the fine search are shown enclosed by a rectangle. The best chipx2 phase is evaluated again so that comparisons can be made over the same set of data. This also allows the coarse search and fine search to use different integration times. The fine search is performed separately for each satellite because each satellite may have a different value for code Doppler.

Fig. 10 provides a time line of the search process when performed in accordance with one embodiment of the invention. The overall processing time (coarse + fine search) is performed in about 1.324 seconds in one embodiment of the invention, which does interrupt the call, but still allows the call to continue once the search is performed. The total search time of

1.324 seconds is an upper bound, because it assumes that the DSP needs to search all 8 satellites and each satellite has a search window of 68 chips. The probability that the entire 1.324 seconds will be necessary is small, however, due to the geometry of the satellite orbits.

During the first 18ms **80**, IQ sample data is collected at the GPS frequency. During the period **82**, a coarse search is performed internally which could last up to 1.13 seconds, but which will probably terminate early when the satellite signals are identified. Once the coarse search is performed, the C/A codes are computed during time period **84**, which takes 24 ms. During time periods **86** the slew value is adjusted for code Doppler and the Rx AGC is further adjusted. During time periods **88**, fine searches are performed on the IQ data samples, with continuous adjustment performed during time periods **86**. The use of 18 ms integration times allows code Doppler to be neglected because the received C/A code phase will be shifted by less than 1/16 of a chip. Up to eight sequences of adjustments and fine searches are performed for the up to eight satellites, at which time the position location procedure is complete.

Additionally, in some embodiments of the invention, the phone continues to transmit reverse link frames to the base station while the position location procedure is performed. These frames may contain null information simply to allow the base station to remain synchronized with the subscriber unit, or the frames may contain additional information such as power control commands or information request. The transmission of these frames is preferably performed when GPS samples are not being gathered when the RF circuitry is available, or while the GPS samples are gathered if sufficient RF circuitry is available.

Although the use of 18ms integration time avoids the effects of code Doppler, the transmission of data over the GPS signals at 50Hz rate can cause problems if a data change occurs within the 18ms processing span (as described above). The data change causes the phase of the signal to shift. The 50Hz data boundaries occur at different places for each satellite. The phase of the 50Hz transitions for each satellite have been effectively randomized by the varying path lengths from each satellite to the phone.

In the worst case, if the data bit was inverted in the middle of a coherent integration interval, the coherent integration could be completely wiped out. For this reason, in an alternative embodiment of the invention, the base station must communicate the data transition boundaries for each satellite to the phone (also described above). Preferably, the data transmission boundary is also included in the aiding message transmitted from the base station (such as in a set of five bit messages indicating the millisecond interval during which the transition occurs for each satellite). The phone uses this boundary to split the coherent integration interval for each satellite into 2 pieces and decide whether to add or subtract the coherent integration sums in these 2 intervals. Thus, by also including the data boundary of each GPS signal, the reliability of the location procedure is increased.

In the exemplary embodiment of the invention, any frequency uncertainty creates a loss in Ec/Nt that increases with the coherent integration time. For example, uncertainty of +/-100Hz, the loss in Ec/Nt increases rapidly as the coherent integration time is increased, as shown in Table I.

Nc	Loss in Ec/Nt
1023 (1ms)	0.14 dB
2046 (2ms)	0.58 dB
4092 (4ms)	2.42 dB
6138 (6ms)	5.94 dB
8184 (8ms)	12.6 dB

Table I.

As also noted above, there is always some unknown frequency offset of the local oscillator in the mobile unit. It is this unknown frequency offset that prevents longer coherent despreading and integration from being performed. Longer coherent would improve processing if the effects of the unknown frequency offset could be reduced.

In one embodiment of the invention, this unknown frequency offset is accounted for by expanding the search space to 2 dimensions to include frequency searches. For each hypothesis, several frequency searches are performed, where each frequency search assumes the frequency offset is a known value. By spacing the frequency offsets, one can reduce the frequency uncertainty to an arbitrarily small value at the expense of added computation and memory. For example, if 5 frequency hypotheses are used, the resulting search space is shown in **Fig. 10**.

For a +/-100Hz frequency uncertainty, which is the typically operating specification of a mobile unit, this configuration reduces the maximum frequency offset to 20Hz (one hypothesis must be within 20Hz of the actual frequency offset). With a 20ms coherent integration time, the loss in Ec/Nt with a 20Hz frequency offset is 2.42 dB. By doubling the number of frequency hypotheses to 10, the frequency uncertainty can be reduced to 10Hz, which causes an Ec/Nt loss of .58dB. However, adding additional hypotheses widens the search space, which increases both the computation and memory requirements.

One embodiment of the invention computes the frequency hypothesis by lumping the frequency offset in with the frequency Doppler, and computing a new rotated PN code for each frequency hypothesis. However, this makes the number of frequency hypotheses a multiplicative factor in the total computation: 5 frequency hypotheses would mean 5 times as much computation.

Alternatively, since the frequency uncertainty is small compared to the frequency Doppler, the rotation phase can be considered to be constant over a 1ms interval (8% of a period for an 80Hz hypothesis) in another embodiment of the invention. Therefore, by dividing the coherent integration interval up into 1ms subintervals, the integration sums of the subintervals are rotated to reduce the added computations needed to compute the frequency searches by three orders of magnitude. The result is that longer coherent despreading can be performed, and performance improved.

Fig. 12 is a block diagram of a receiver configured in accordance with the use of longer coherent despreading approach. The first set of multipliers **50** compensates for the frequency Doppler by correlating the IQ samples with a rotated C/A code. This is equivalent to rotating the IQ samples before correlation with the unmodified C/A code. Since the frequency Doppler can be as large as 4500Hz, the rotation is applied to every chip. After coherently integrating over a 1ms interval (1023 chips) using accumulators **52**, the second set of multipliers **54** rotates the 1ms integration sums (Σ_I and Σ_Q) to implement the frequency hypothesis. The rotated sums are then added over the whole coherent integration interval.

Recall that the frequency Doppler rotation was only computed on 1023 chips to save memory and computation. For coherent integration times longer than 1ms, each coherent integration sum are multiplied by a phase offset to make the phase of the rotation continuous over time. To show this mathematically, the 1ms coherent integration sum with frequency Doppler rotation can be expressed as:

$$S_1 = \sum_{n=1}^{1023} [I(n) + jQ(n)]c(n)e^{-jw_d nT_c} \text{ with } \Sigma_I = \mathrm{Re}\{S_1\} \text{ and } \Sigma_Q = \mathrm{Im}\{S_1\}$$

where I(n) and Q(n) are the input samples received on the I and Q channels respectively, c(n) is the unrotated C/A code, w_d is the frequency Doppler, and T_c is the chip interval (.9775us). A 2ms coherent integration sum can be expressed as:

$$S(2ms) = \sum_{n=1}^{2046} [I(n) + jQ(n)]c(n)e^{-jw_d nT_c}$$

$$= \sum_{n=1}^{1023} [I(n) + jQ(n)]c(n)e^{-jw_d nT_c} \quad + \quad e^{-jw_d(1023)T_c} \sum_{n=1}^{1023} [I(n+1023) + jQ(n+1023)]c(n)e^{-jw_d nT_c}$$

$$= S_1 \quad + \quad e^{-jw_d(1023)T_c} S_2$$

Here, S_1 is the first 1ms integration sum and S_2 is the second 1ms integration sum computed using the same rotated C/A values that were used to compute S_1. The term $e^{-jwd(1023)Tc}$ is the phase offset that compensates for using the same rotated values. Similarly, a 3ms coherent integration sum can be expressed as

$$S(3ms) \quad = \quad S_1 \quad + \quad e^{-jw_d(1023)T_c} S_2 \quad + \quad e^{-jw_d(2046)T_c} S_3$$

So to extend the integration time while using the same 1023-element rotated C/A sequence, the (n+1) 1ms integration sum should be multiplied by $e^{-jwdn(1ms)}$ before being added to the whole sum. Since this is a rotation of 1ms integration sums, we can combine this operation with the frequency search to avoid having to perform 2 rotations. That is, since

$$e^{-jw_d n(1ms)} e^{-jw_k n(1ms)} \quad = \quad e^{-j(w_d + w_k) n(1ms)}$$

we can multiply the (n+1)th 1ms integration sum by $e^{-j(wd+wh)n(1ms)}$ to search a frequency hypothesis and account for the frequency Doppler phase offset.

Note that the frequency search can be reduced after acquiring one satellite, because the frequency uncertainty is not dependent on the satellite. A much finer frequency search can be performed if a longer coherent integration is desired.

In the exemplary embodiment of the invention, the fine search is performed in similar manner the coarse search with 2 differences. First, the integration intervals are always added coherently instead of squaring and adding noncoherently. Second, the rotation to remove the frequency uncertainty (which should be known after the coarse search) is combined with the frequency Doppler phase offset and used to rotate the 1ms coherent integration intervals before adding them together.

In an alternative embodiment of the invention, the coherent integration window of chipx2 data is integrated for integration times longer than 18ms. This embodiment is useful were additional memory is available. For coherent integrations longer than 18ms, the 50Hz data boundaries are treated the same as with shorter integration periods. The base station indicates where the boundaries are for each satellite and the DSP decides whether to add or subtract the sum of 20 1ms coherent integration intervals to or from its running sum.

However, because the product of the frequency uncertainty and the integration time constant affects the loss in Ec/Nt, the frequency uncertainty must be reduced to very small levels for long coherent integration intervals. Since a 20ms integration with a 20Hz frequency uncertainty resulted in a loss in Ec/Nt of 2.42 dB, maintaining the same loss with an integration time of 400ms requires that the frequency uncertainty be reduced to 1Hz. To correct for this problem, the frequency uncertainty is reduced down to 1Hz in a hierarchical manner. For example, a first frequency search reduces the uncertainty from 100Hz to 20Hz, a second search reduces the uncertainty to 4 Hz, and a third search reduces the uncertainty to 1Hz. The frequency search will also compensate for errors in the frequency Doppler obtained from the base station.

Additionally, to perform longer integrations only satellites with similar Doppler are searched over the same data for long integration times, since the code Doppler is different for each satellite. The DSP computes how long it takes to slip 1/16 of a chip and slews the decimator as it collects a coherent integration data window. Additionally, multiple data windows are taken in this embodiment.

Thus, a method and apparatus for performing position location in wireless communications system has been described. The previous description of the preferred embodiments is provided to enable any person skilled in the art to make or use the present invention. The various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without the use of the inventive faculty. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

WHAT IS CLAIMED IS:

12

CLAIMS

1. A method for performing position location comprising the steps of:

(a) receiving signal samples;

(b) generating a coarse acquisition sequence;

(c) rotating said coarse acquisition sequence yielding a rotated coarse acquisition sequence;

(d) applying said rotated coarse acquisition sequence to said signal samples at a set of time offsets yielding correlated output data.

2. The method as set forth in claim 1 further comprising the step of accumulating said correlated output data.

3. The method as set forth in claim 2 wherein step (d) comprises the steps of:

performing coherent integration;

performing non-coherent integration.

4. The method of claim 1 wherein a coarse search is performed, followed by a fine search.

5. The method as set forth in 3 wherein said coherent integration is performed over a first duration, and said non-coherent integration is performed over a second duration.

6. The method as set forth in 5 wherein said first duration is approximately one ms.

7. The method as set forth in claim 3 wherein said non-coherent integration is performed on results generated from said coherent integration.

8. The method as set forth in claim 1 further comprising the step of storing said rotated coarse acquisition sequence.

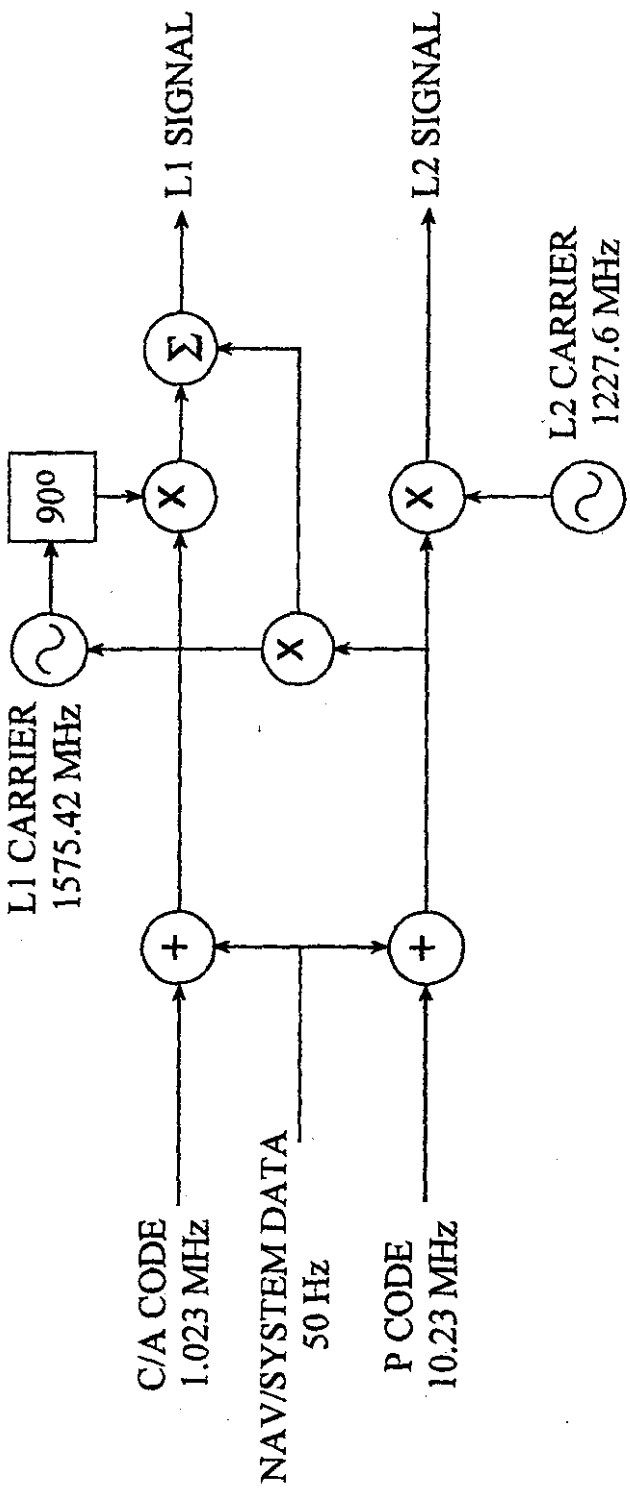

L1 SIGNAL
L2 SIGNAL
90°
Σ
L1 CARRIER
1575.42 MHz
L2 CARRIER
1227.6 MHz
C/A CODE
1.023 MHz
NAV/SYSTEM DATA
50 Hz
P CODE
10.23 MHz

FIG. 1

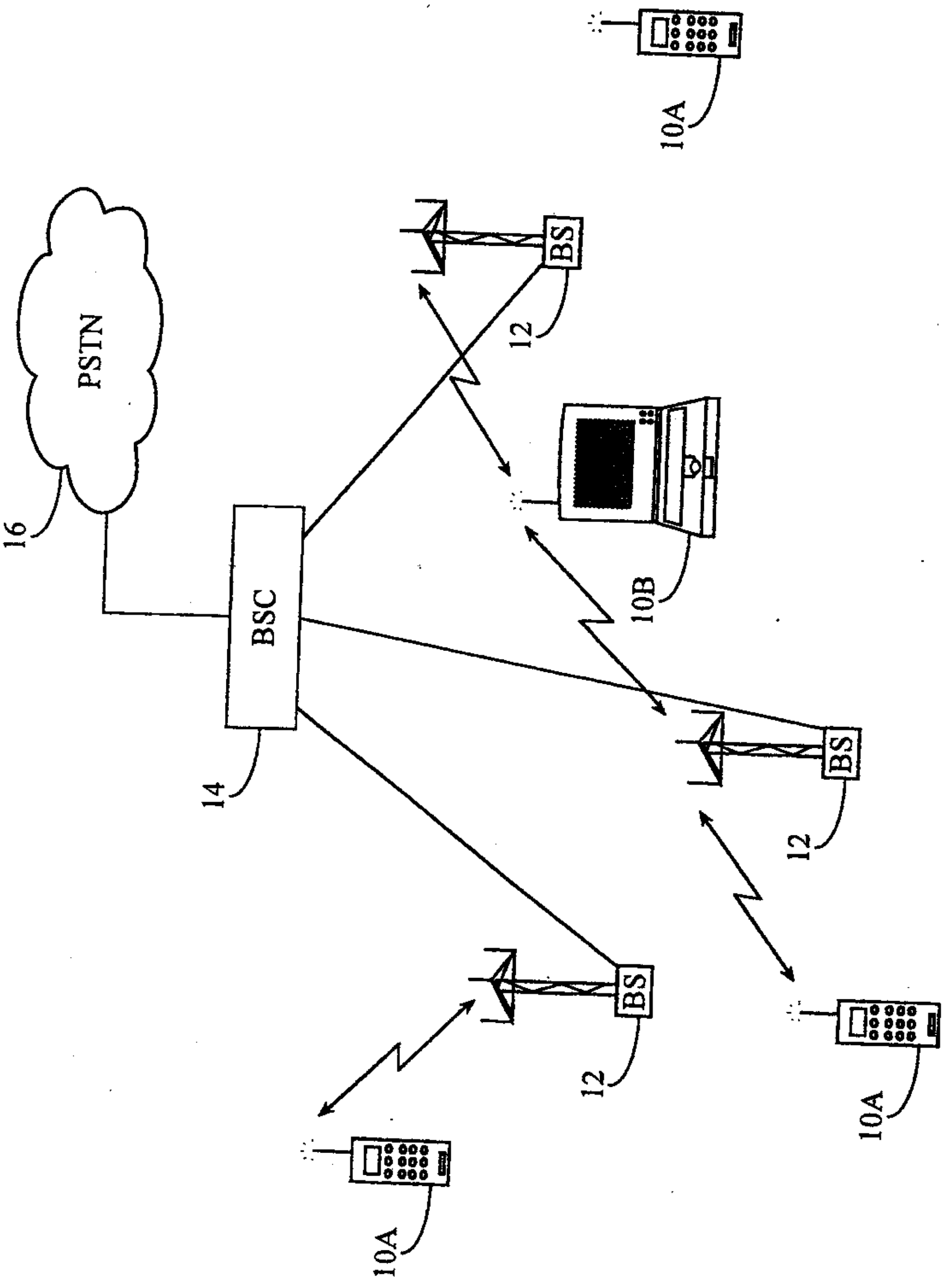


FIG. 2

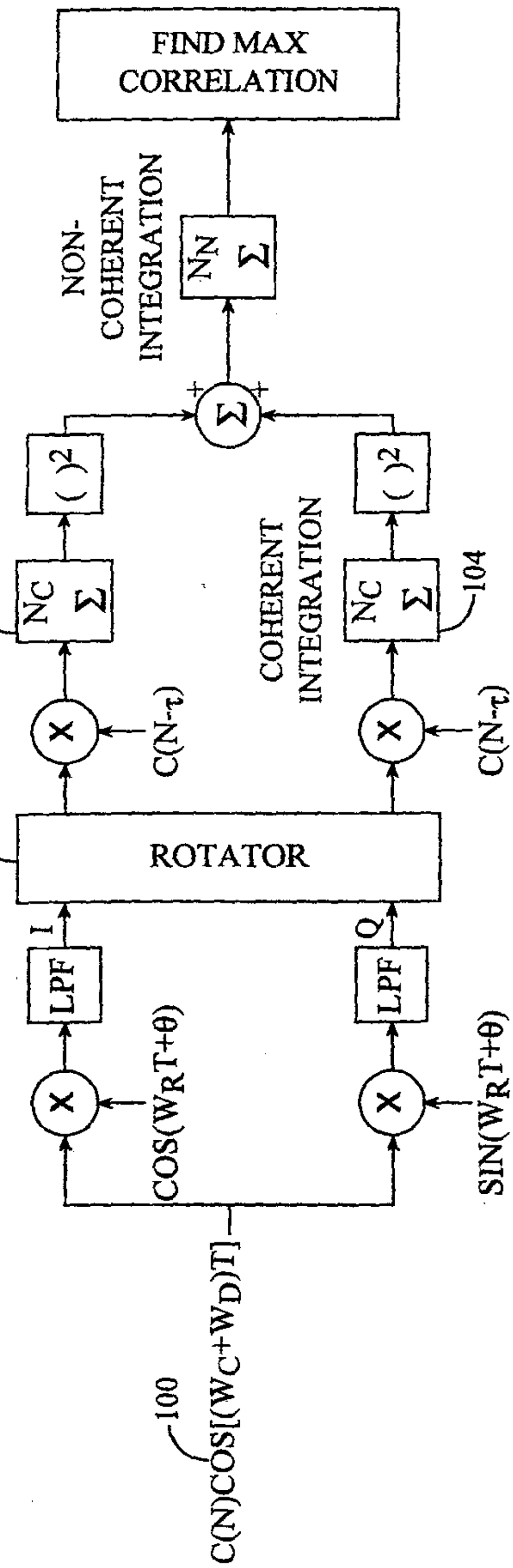

FIND MAX
CORRELATION
NON-
COHERENT
INTEGRATION
N_N
Σ
+
+
Σ
( )²
( )²
COHERENT
INTEGRATION
104
N_C
Σ
104
N_C
Σ
X
C(N-τ)
X
C(N-τ)
102
ROTATOR
I
Q
LPF
LPF
X
COS(W_RT+θ)
X
SIN(W_RT+θ)
100
C(N)COS[(W_C+W_D)T]

FIG. 3

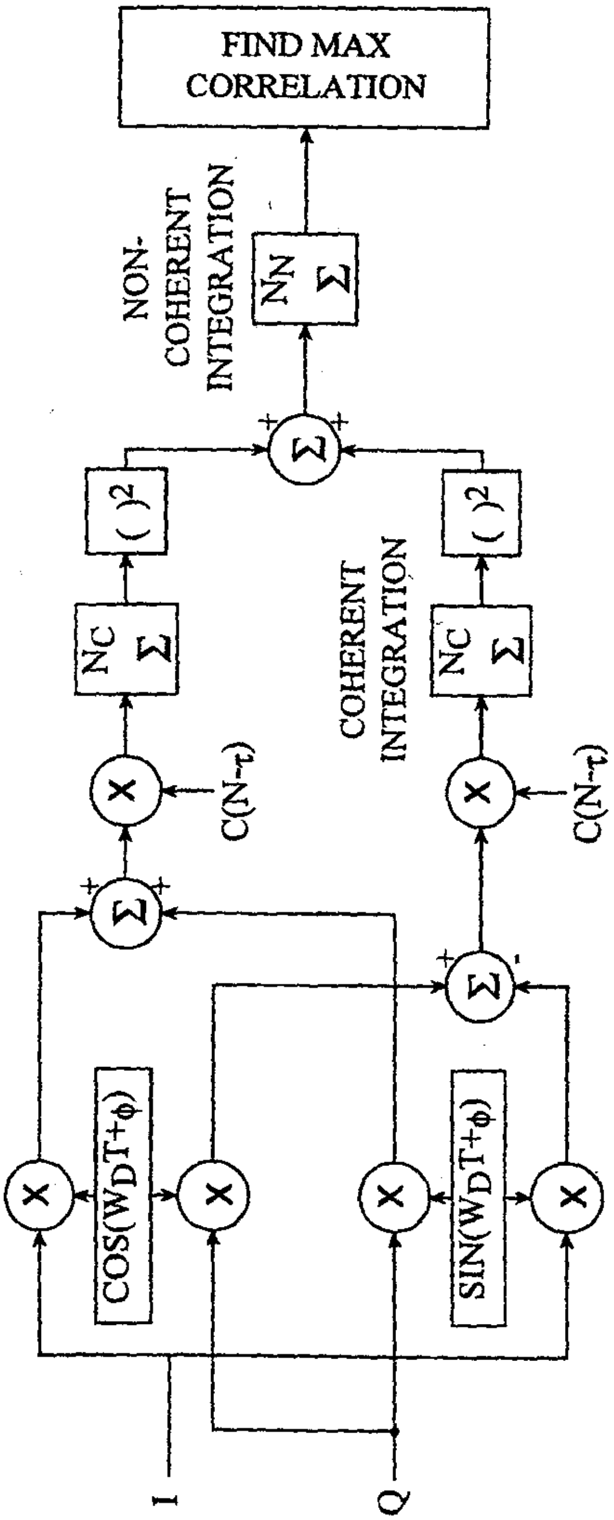

FIND MAX CORRELATION
NON-COHERENT INTEGRATION
COHERENT INTEGRATION
N_N Σ
N_C Σ
( )^2
C(N-τ)
COS(W_DT+φ)
SIN(W_DT+φ)
I
Q

FIG. 4

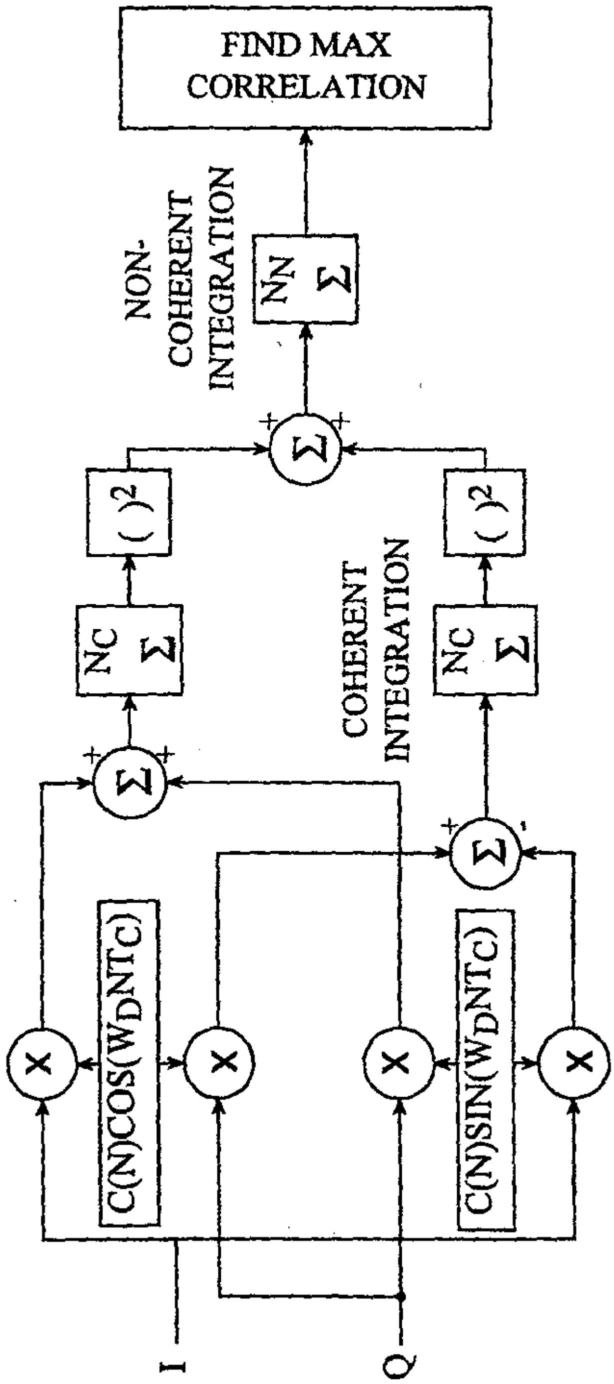

FIND MAX
CORRELATION
NON-
COHERENT
INTEGRATION
COHERENT
INTEGRATION
C(N)COS(WDNTC)
C(N)SIN(WDNTC)
I
Q

FIG. 5

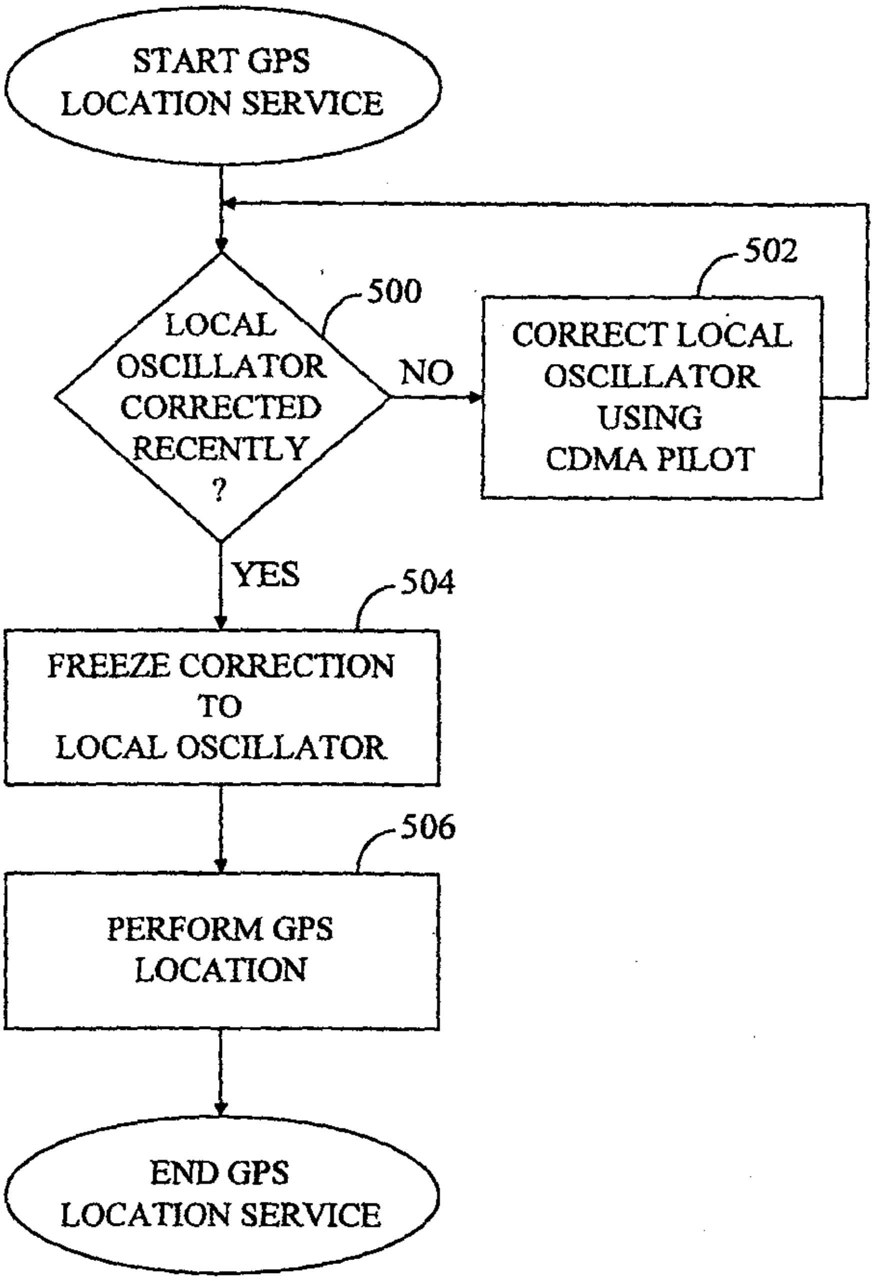

START GPS LOCATION SERVICE
LOCAL OSCILLATOR CORRECTED RECENTLY ?
500
NO
502
CORRECT LOCAL OSCILLATOR USING CDMA PILOT
YES
504
FREEZE CORRECTION TO LOCAL OSCILLATOR
506
PERFORM GPS LOCATION
END GPS LOCATION SERVICE

FIG. 6

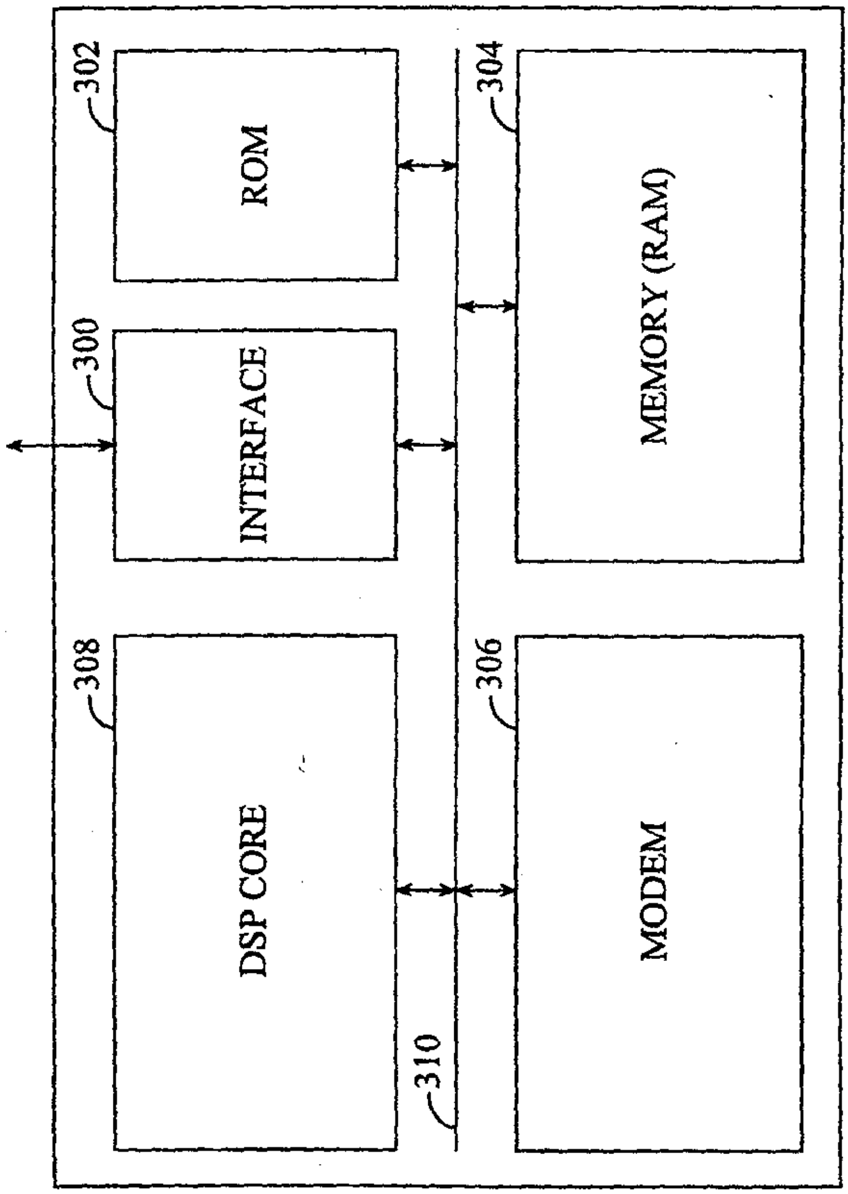

ROM
302
INTERFACE
300
DSP CORE
308
MEMORY (RAM)
304
MODEM
306
310

FIG. 7

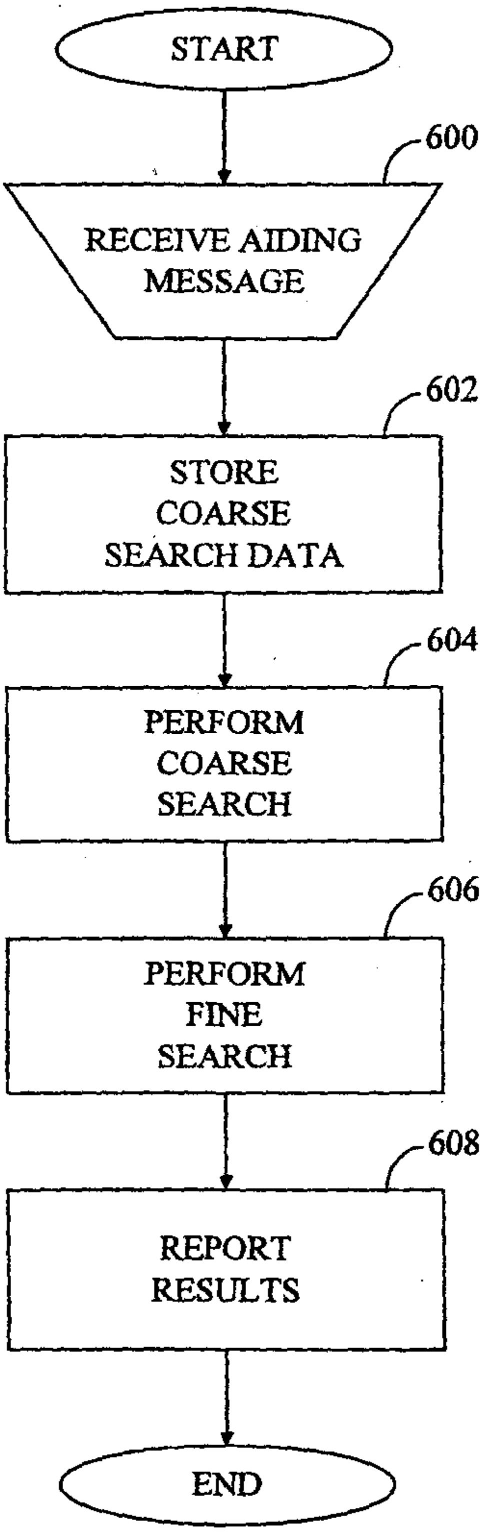

START
600
RECEIVE AIDING MESSAGE
602
STORE COARSE SEARCH DATA
604
PERFORM COARSE SEARCH
606
PERFORM FINE SEARCH
608
REPORT RESULTS
END

FIG. 8

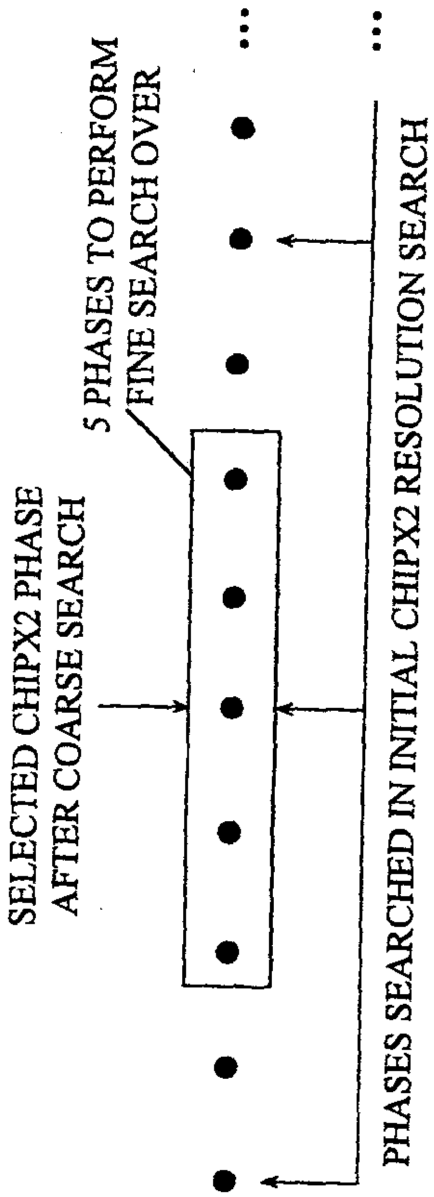

SELECTED CHIPX2 PHASE
AFTER COARSE SEARCH
5 PHASES TO PERFORM
FINE SEARCH OVER
PHASES SEARCHED IN INITIAL CHIPX2 RESOLUTION SEARCH

FIG. 9

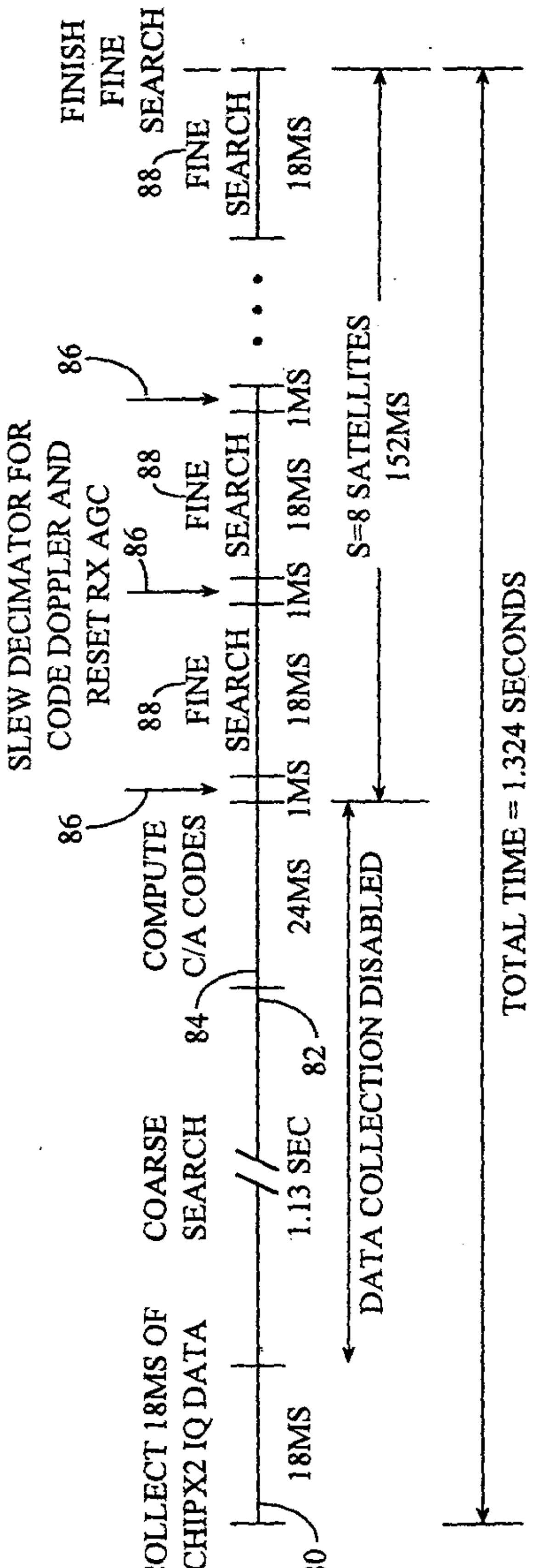

COLLECT 18MS OF CHIPX2 IQ DATA
80
18MS
COARSE SEARCH
1.13 SEC
84
82
COMPUTE C/A CODES
24MS
86
SLEW DECIMATOR FOR CODE DOPPLER AND RESET RX AGC
1MS
88
FINE SEARCH
18MS
86
1MS
88
FINE SEARCH
18MS
86
1MS
88
FINE SEARCH
18MS
FINISH FINE SEARCH
DATA COLLECTION DISABLED
S=8 SATELLITES
152MS
TOTAL TIME = 1.324 SECONDS

FIG. 10

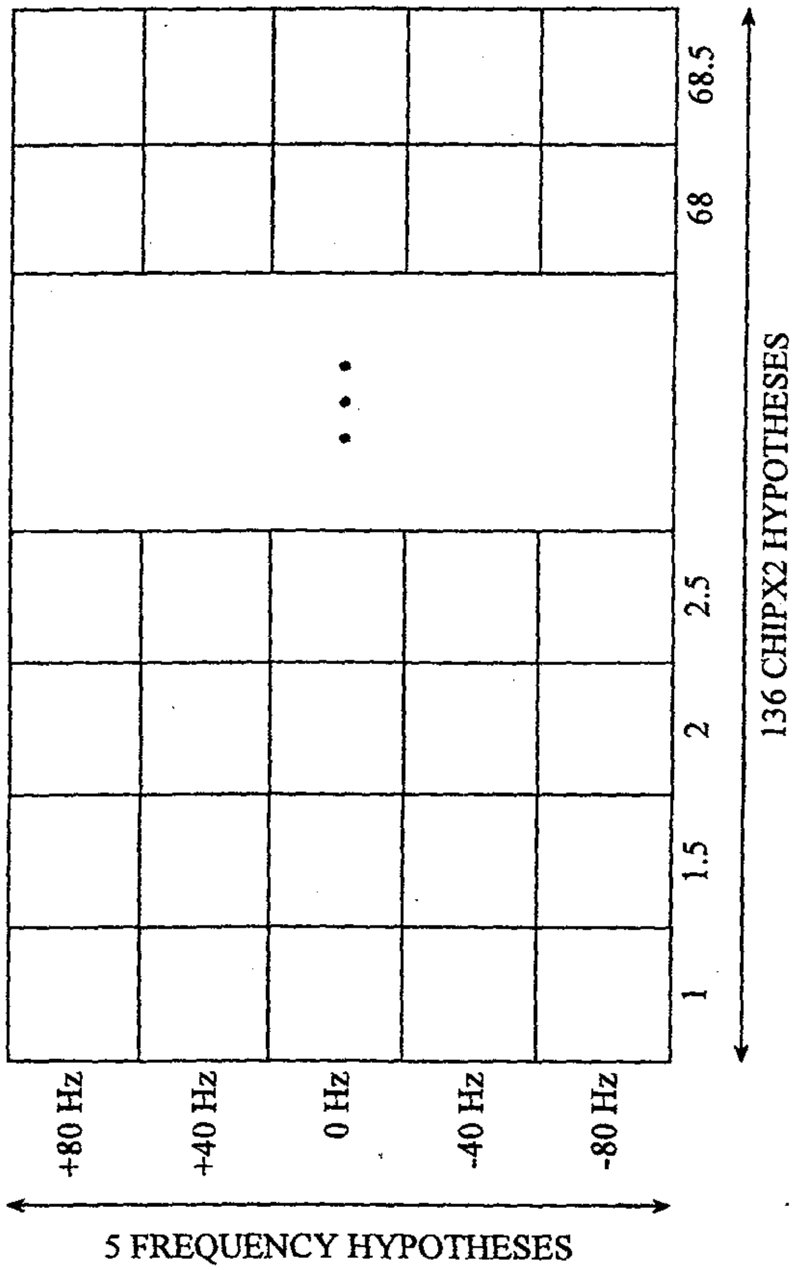

136 CHIPX2 HYPOTHESES
1
1.5
2
2.5
68
68.5
+80 Hz
+40 Hz
0 Hz
-40 Hz
-80 Hz
5 FREQUENCY HYPOTHESES

FIG. 11

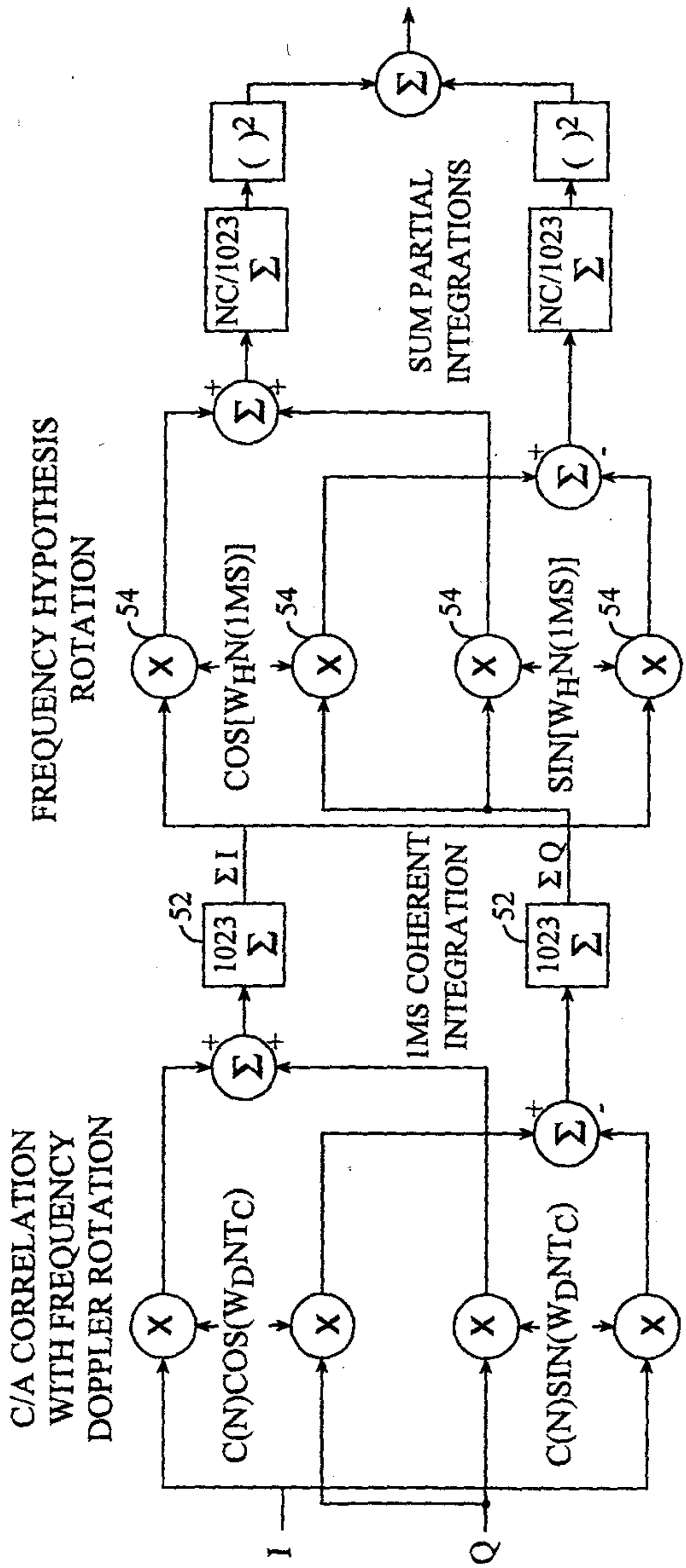

C/A CORRELATION WITH FREQUENCY DOPPLER ROTATION
C(N)COS(WDNTC)
C(N)SIN(WDNTC)
I
Q
1MS COHERENT INTEGRATION
1023
52
ΣI
ΣQ
FREQUENCY HYPOTHESIS ROTATION
COS[WHN(1MS)]
SIN[WHN(1MS)]
54
SUM PARTIAL INTEGRATIONS
NC/1023
( )2

FIG. 12

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/20280

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01S5/14 G01S5/00

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01S

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 practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 495 499 A (FENTON PATRICK ET AL) 27 February 1996 (1996-02-27) column 6, line 24 -column 13, line 42	1-8
X	US 5 117 232 A (CANTWELL ROBERT H) 26 May 1992 (1992-05-26) column 5, line 44 -column 7, line 55	1-8
A	US 5 781 156 A (KRASNER NORMAN F) 14 July 1998 (1998-07-14) abstract	

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

☒ Patent family members are listed in 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 but 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
22 December 1999	12/01/2000

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

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte. ...nal Application No
PCT/US 99/20280

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5495499 A	27-02-1996	US 5390207 A	14-02-1995
		US 5101416 A	31-03-1992
		US 5809064 A	15-09-1998
		US 5734674 A	31-03-1998
		AU 660757 B	06-07-1995
		AU 3197193 A	29-07-1993
		CA 2087909 A	25-07-1993
		CN 1080059 A,B	29-12-1993
		EP 0552975 A	28-07-1993
		SG 43672 A	14-11-1997
		US 5414729 A	09-05-1995
		CA 2055105 A,C	29-05-1992
		DE 69121066 D	29-08-1996
		DE 69121066 T	30-01-1997
		DE 488739 T	20-04-1995
		EP 0488739 A	03-06-1992
		JP 2931462 B	09-08-1999
		JP 4269682 A	25-09-1992
		SG 43678 A	14-11-1997
US 5117232 A	26-05-1992	AU 643272 B	11-11-1993
		AU 7649091 A	05-12-1991
		CA 2042522 A	05-12-1991
		DE 69129132 D	30-04-1998
		DE 69129132 T	12-11-1998
		EP 0460862 A	11-12-1991
		ES 2113365 T	01-05-1998
		HK 1010062 A	11-06-1999
		JP 2839211 B	16-12-1998
		JP 4232485 A	20-08-1992
US 5781156 A	14-07-1998	US 5663734 A	02-09-1997
		AU 7396096 A	30-04-1997
		AU 7397396 A	30-04-1997
		AU 7662096 A	30-04-1997
		CA 2230841 A	17-04-1997
		CN 1199468 A	18-11-1998
		CN 1211324 A	17-03-1999
		EP 0880713 A	02-12-1998
		EP 0855039 A	29-07-1998
		WO 9714053 A	17-04-1997
		WO 9714049 A	17-04-1997
		WO 9714056 A	17-04-1997
		US 5831574 A	03-11-1998
		US 5825327 A	20-10-1998

[19]中华人民共和国国家知识产权局

[51]Int. Cl⁷

G01S 5/14

G01S 5/00

[12]发明专利申请公开说明书

[21]申请号 99810724.7

[43]公开日 2001年10月24日 [11]公开号 CN 1319190A

[22]申请日 1999.9.3 [21]申请号 99810724.7

[30]优先权

[32]1998.9.9 [33]US [31]09/150,074

[86]国际申请 PCT/US99/20280 1999.9.3

[87]国际公布 WO00/14567 英 2000.3.16

[85]进入国家阶段日期 2001.3.9

[71]申请人 夸尔柯姆股份有限公司

地址 美国加州圣地埃哥

[72]发明人 I·康 G·C·斯

周群真

[74]专利代理机构 上海专利商标事务所

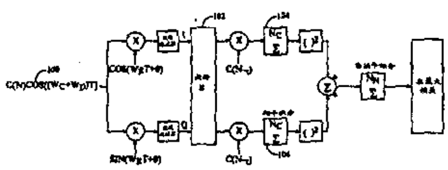
代理人 李家麟

权利要求书1页 说明书12页 附图页数12页

[54]发明名称 用有效旋转器进行定位的接收机

[57]摘要

本发明是一种新的、改进的在无线通信系统中进行定位的方法和装置。本发明的一种实施例包含一种进行定位的方法，它包含接收信号取样、产生粗捕获序列、使所述粗捕获序列旋转而产生旋转的粗捕获序列，以及在一组时移处使所述旋转的粗捕获序列作用于所述信号取样而产生相关的输出数据的步骤。



ISSN1008-4274

知识产权出版社出版

权 利 要 求 书

1. 一种进行定位的方法，其特征在于，它包含下述步骤：

(a) 接收信号取样；

(b) 产生粗捕获序列；

(c) 使所述粗捕获序列旋转，产生旋转的粗捕获序列；

(d) 在一组时移处使所述旋转的粗捕获序列作用于所述信号取样，产生相关的输出数据。

2. 如权利要求 1 所述的方法，其特征在于，它还包含累加所述相关输出数据的步骤。

3. 如权利要求 2 所述的方法，其特征在于，步骤(d)包含下述步骤：

进行相干积分；

进行非相干积分。

4. 如权利要求 1 所述的方法，其特征在于，进行粗搜寻，随后进行细搜寻。

5. 如权利要求 3 所述的方法，其特征在于，所述相干积分是在第一时间区间内进行的，而所述非相干积分是在第二时间区间内进行的。

6. 如权利要求 5 所述的方法，其特征在于，所述第一时间区间近似为 1 毫秒。

7. 如权利要求 3 所述的方法，其特征在于，所述非相干积分是对由所述相干积分所产生的结果进行的。

8. 如权利要求 1 所述的方法，其特征在于，它还包含存储所述旋转的粗捕获序列的步骤。

说　　明　　书

用有效旋转器进行定位的接收机

发明背景

I. 发明领域

本发明涉及定位。更具体地说，本发明涉及一种在无线通信系统中执行定位的新的、改进的方法和装置。

II. 相关技术领域描述

无论是政府还是客户都要求在蜂窝电话中具有定位功能。当前的全球定位系统(GPS)可以采用 GPS 接收机和一组地球轨道卫星来进行定位。因此，就要求在蜂窝电话中引入 GPS 功能。

然而，蜂窝电话对成本、重量和功耗极为敏感。因此，仅仅增加进行 GPS 定位的附加电路在蜂窝电话中提供定位功能还远远不够。所以，本发明在蜂窝电话系统中以最小的附加硬件、成本和功耗来提供 GPS 功能。

发明概述

本发明是一种在无线通信系统中执行定位的新的、改进的方法和装置。本发明一种实施例包含了一种执行定位的方法，它包含下述步骤：接收取样信号、产生粗捕获序列(coarse acquisition sequence)、使所述粗捕获序列旋转而产生旋转的粗捕获序列，以及在一组时移处使所述旋转的粗捕获序列作用于所述取样信号而产生相关的输出数据。

附图简述

读者在结合附图阅读了本发明的详细描述以后，将更清楚地理解本发明的特征、目的和优点。图中，相同的标号所表示的意义相同。

图 1 是全球定位系统(GPS)波形发生器的方框图；

图 2 是按照本发明的用途而配置的蜂窝电话系统高度简化的方框图；

图 3 是按照本发明一种实施例而构成的接收机方框图；

图 4 是图 3 中所示接收机的另一方框图；

图 5 是按照本发明另一种实施例而构成的接收机；

图 6 是定位操作期间执行的步骤的流程图；

图 7 是按照本发明一种实施例而构成的 DSP 方框图；

图 8 是在按照本发明一种实施例而执行的搜寻期间所执行的步骤的流程图；

图 9 是本发明一种实施例中所执行的粗搜寻和细搜寻时的相位的等时线(time line)；

图 10 是按照本发明一种实施例所执行的搜寻处理的等时线；

图 11 是搜寻空间的图；

图 12 是按照本发明另一实施例的接收机。

较佳实施例的详细描述

下面描述无线通信系统中执行定位的新的、改进的方法和装置。结合数字蜂窝电话系统来描述典型的实施例。尽管这样做有很多好处，但应当理解，本发明不同的实施例可以应用于各种不同的场合或结构。通常，这里所描述的各种系统可以用软件控制的处理器、集成电路或分立的逻辑电路来形成，但最好采用集成电路结构。整个应用中将被涉及的数据、指令、命令、信息、信号、符号和码片(chip)最好用电压、电流、电磁波、磁场或磁子(magnetic particle)、光场或光子(optical particle)或其组合来表示。另外，每一方框图中的方框可以代表硬件或者方法的步骤。

图 1 是全球定位系统(GPS)波形发生器的方框图。带有加号的圆圈代表模 2 相加。通常，GPS 星座由 24 个卫星组成：用于导航的 21 艘宇宙飞船(SV)，和 3 个用于备用的宇宙飞船。每一 SV 含有一个时钟，该时钟通过监视地面站而与 GPS 时间同步。为了确定位置和时间，一 GPS 接收机对从几个卫星接收的信号进行处理。在求解 4 个未知数(x, y, z, 时间)时，必须至少使用 4 个卫星。

每一 SV 发送两种微波载波：载送用于标准定位服务(SPS)的信号的 1575.42 MHz L1 载波，以及载送进行精确定位服务(PPS)所需信号的 1227.60 MHz L2 载波。PPS 用于政府机构，它具有更高的定位精度。

L1 载波用粗捕获(C/A)码调制，这一 C/A 码是一种用于民用定位服务而在 1.023 Mcps 下传送的 1023—码片的伪随机码。(请不要将粗捕获码和本文中的粗、细捕获相混淆，尽管两者都使用了 C/A 码。)每一卫星都拥有其自己的、每隔 1ms 重复一次的 C/A 码。用于 PPS 的 P 码是一种长度为 267 天的 10.23MHz 码。两种载波上都有 P 码，但 P 码与 L1 载波上的 C/A 码相位偏移 90 度。与 C/A 码和 P 码在

进行载波调制前经过异或的 50Hz 导航消息用来提供系统信息，如卫星轨道和时钟校正。

L1 由粗捕获(C/A)码调制，该 C/A 码是一种用于民用定位服务并且在 1.023Mcps 下传送的 1023 码片的伪随机码。每一卫星有其自己的每隔 1ms 重复一次的 C/A 码。用于 PPS 的 P 码是长度为 267 天的 10.23MHz 码。在两者载波上出现的 P 码与在 L1 载波上的 C/A 码相比，相位相差 90 度。与 C/A 码和 P 码在进行载波调制前而进行异或的 50Hz 导航消息提供系统信息，如卫星轨道和时钟校正。

L1 载波由粗捕获(C/A)码调制，该粗捕获码是一种用于民用定位服务而在 1.023Mcpc 下传送的 1023 码片伪随机码。每一卫星有其自己的每隔 1ms 重复一次的 C/A 码。用于 PPS 的 P 码是长度为 267 天的 10.23MHz 码。在两种载波上出现的 P 码与在 L1 载波上的 C/A 码在相位上相差 90 度。在载波调制前与 C/A 码和 P 码进行异或的 50Hz 导航消息提供系统信息，如卫星轨道和时钟校正。

每一卫星具有不同的 C/A 码，而这些不同的 C/A 码属于称作金码的一族码。采用金码是因为它们之间的交叉相关较小。C/A 码是用如图 1.4-2 下面的两个 10 级移位寄存器来产生的。G1 发生器采用多项式 $1+X^3+X^{10}$，而 G2 发生器采用多项式 $1+X^{2}+X^3+X^6+X^8+X^9+X^{10}$。C/A 码是通过将 G1 移位寄存器的输出与 G2 移位寄存器的两个位进行异或运算来产生的。

图 2 是按照本发明构成的蜂窝电话系统高度简化的方框图。移动电话 10 位于基站 12 之间，而基站 12 与基站控制器(BSC) 14 耦合。移动交换中心 MSC 16 将 BSC 14 与公共电话交换网(PSTN)相连。工作时，某些移动电话通过与基站 12 接口相连进行电话呼叫，而另一些则处于等待状态。

正如已转让给本发明受让人且在此引述供参考的、标题是“确定无线 CDMA 收发机的位置的系统和方法”的共同待批的美国专利申请 09/040,051 中所描述的那样，通过传送含有“辅助信息”的定位请求消息从而使移动电话能够快速捕获 GPS 信号，可以便于进行定位。该信息包括 SV 的识别(ID)号(SV ID)、估算的编码相位、估算编码相位周围的搜寻窗大小以及估计的频率多普勒效应。采用该信息，移动单元可以捕获 GPS 信号，并且更快地确定其位置。

根据辅助消息，移动单元调谐到 GPS 频率，并开始将所接收的信号与其由基站所指示的、本地产生的用于 SV 的 C/A 序列相关。它采用辅助信息使搜寻空间变窄以及补偿多普勒效应，并采用时间相关来获得每一卫星的伪距。注意，这些伪距是基于移动单元时间的(它是从 CDMA 接收机组合器系统时间计数器得到的)，而

该移动单元时间是 GPS 时间的延迟形式。

在计算了这一信息以后，移动单元发送每一卫星的伪距(最好是 1/8 码片的分辨率)，以及对基站进行测量的时间。随后，移动单元再调谐到 CDMA，继续进行呼叫。

在接收到该信息以后，BSC 使用单向延迟估计将伪距从移动单元时间转换成基站时间，并通过求解几个球面的交点来计算移动单元的估计位置。

辅助消息所提供的另一个参数是频率多普勒或多普勒偏移。多普勒效应表示由于发射机和接收机之间的相对速度而引起的接收信号频率的明显改变。载波上多普勒效应称作是频率多普勒，而基带信号上的效应称作是编码多普勒。

在 GPS 的情况下，频率多普勒改变所接收的载波频率，所以其效应是与采用载波偏移进行的解调是相同的。由于基站 GPS 接收机是主动跟踪所要求的卫星的，所以它知道由卫星的移动而引起的频率多普勒。另外，卫星与基站与移动单元相隔甚远，从而移动单元所看到的多普勒在效果上与基站所看到的多普勒是相同的。在本发明的一种实施例中，为了校正频率多普勒值，移动单元在接收机中采用了旋转器。频率多普勒的范围在-4500Hz 到+4500Hz 内，而变化率在 1Hz/s 的数量级。

编码多普勒的作用是改变 1.023MHz 码片速率，该速率有效地压缩或扩展了所接收的 C/A 码片。在本发明的一种实施例中，移动单元通过将频率多普勒乘以比值 1.023/1575.42，校正了编码多普勒。于是，移动单元可以通过在必要时使所接收的 IQ 取样的相位以 1/16 码片增量偏移(即在其中引入延迟)，在时间上来校正编码多普勒。

图 3 是按照本发明一种实施例构成的蜂窝电话(无线用户单元)接收机部分的方框图。接收波形 100 被模拟成用频率为 w_c+w_d 的载波调制的 C/A 信号 c(n)，这里，w_c 是标称载波频率 1575.42MHz，而 w_d 是由卫星的移动所产生的多普勒频率。多普勒频率范围从卫星直接位于头顶上方时的 0 频率到处于最坏时的约 4.5kHz。接收机模拟部分可以被模拟成频率为 w_r 和随机相位 θ 的载波来解调，随后进行低通滤波。

所产生的基带信号通过一个 A/D 转换器(未示出)，产生数字 I、Q 取样，并且存储起来，从而可以重复进行搜寻。取样是在二倍于 C/A 编码码片速率(码片×2)下产生的，该速率是一个小于进行细搜寻所必须的分辨率，但它使得 18ms 的取样数据能够存储在一个合理数量的存储器内。通常，要求在大于 10ms 的速率下搜寻某样东西，以便能够在大多数环境下进行捕获，并且这时 18ms 是较佳的积分时

间。这些环境包括内部的，或者是不能直接看到卫星的地方。

运行时，取样首先由旋转器 102 旋转，以校正多普勒频移。旋转的 I 和 Q 取样与卫星的 C/A 序列的各种时移相关，并且将结果由积分器 104 在 Nc 个码片的时间内进行相干积分。相干积分的和取平方，并且相加，以去掉未知相移 θ 的影响。为了扩大对特定偏移的假设试验，非相干地将几个相干持续时间(interval)组合起来。这一去扩展在各时移内重复进行，以找到卫星信号的时移。旋转器 102 去掉由卫星移动所产生的频率多普勒。它采用基站所规定的多普勒频率(最好量化为 10Hz 时间间隔)，并旋转 I 和 Q 取样以去掉频移。

在本发明的一种实施例中，旋转仅在相干积分窗口上是连续的。即，旋转器在如 1ms 的相干积分周期之间停止。所有的相位差由平方和来消除。

图 4 是按照本发明一种实施例构成的接收机的另一方框图，图中，更详细地绘出了接收机的旋转器部分。

图 5 是按照本发明另一种实施例构成的接收机。本发明这一内部实施例的优点是具有这样的能力，即，通过使本地产生的 C/A 序列而不是输入取样旋转，而使旋转器停止在相干积分周期之间。

如图所示，C/A 序列 c(n)是通过作用于 $\sin(W_d n T_C)$和 $\cos(W_d n T_C)$而旋转并且随后存储起来的。C/A 序列的旋转对于每一卫星只需进行一次。所以，使 C/A 序列旋转减少了所需的计算。它还节省了在本发明一种实施例中进行这种计算所使用的 DSP 中的存储器。

劣化定位特性的另一个重要的影响是在移动单元内部时钟中出现的频率误差。正是由于这一频率误差，使得人们在 1ms 的数量级上使用短相干积分时间(coherent integration time)。最好在更长的时间里进行相干积分。

在示例性结构中，移动单元自由运行(内部)本机振荡器时钟是 19.68MHz 晶体，其频率允差是+/-5ppm。这会引起数量级在+/-7500 Hz 的大的误差。这一时钟用来产生用了 GPS 信号解调的载波，所以时钟误差将被加到信号捕获时间里。由于可以用来搜寻的时间很短，所以因该频率允差而产生的幅度误差是不能允许的，必须大大减小。

为了能够有更长的相干积分时间，在本发明的一种实施例中，CDMA 接收机采用从 CDMA 导频得到的定时，或其他有效的定时信息源，来对本机振荡器进行校正。这样就产生一个用来将本机振荡器时钟尽可能调谐到 19.68MHz 的控制信号。控制信号用于本机振荡器时钟，当 RF 单元从 CDMA 切换到 GPS 时，该控制信号被“冻

结(frozen)”。

然而，即使在采用来自基站(或其他源)的定时信息进行校正以后，也还是有其他的时钟误差的。在本发明的一种实施例中，校正后的频率不定性是+/-100Hz。这一剩余误差仍然会降低接收机的性能，并且在通常情况下避免了更长的相干积分时间。在本发明的一种实施例中，通过在比会降低性能的 1ms 更长的时间内进行非相干积分，可以容易地避免这一剩余误差。

还是看图 1，50Hz NAV/系统数据也被调制到 L1 载波上。如果在两个二分之一的相干积分窗之间出现数据转换(0 至 1 或 1 至 0)，那么所得到的相干积分和会因两个二分之一相互抵消而变成零。在最坏的情况下，这将有效地减少非相干累积次数。尽管所有卫星的数据边界是同步的，但由于路径延迟中存在差异，它们不会同时到达移动单元。这一路径延迟有效地使所接收的数据相位随机化。

在本发明的一种实施例中，不同信号上不同数据相位的问题是要将数据相位包括到从基站发送到移动单元的辅助信息中。由于基站正在解调 50Hz 的数据，所以它知道每一卫星会在什么时候发生数据转换。通过利用单向延迟，基站通过指出(20 个中的)哪一个毫秒时间间隔内会出现数据转换，可以用例如(每一卫星)5 个数据位来对数据相位进行编码。

如果相干积分窗跨越 50Hz 的数据边界，那么相干积分就被分成 2 个部分。一个部分在数据边界的前面，而另一个部分在数据边界的后面。例如，如果 En1 是数据边界前面窗口(它是该窗口开头的二分之一)上的相干积分和，而 En2 是在数据边界后面窗口上的相干积分和，那么移动单元就选择 (En1＋En2)(数据延迟相同的时候)和(En1－En2)(数据发生变化的时候)中最大值(幅度上)来计算相位变化。移动单元还可以这样选择，即在该数据窗上将两个二分之一进行非相干组合，或者完全避开该数据窗口。

在本发明的另一种实施例中，通过比较和的平方值以及 1ms 相干积分的差，移动单元可以发现数据转换而无需来自基站的辅助信息。

在本发明的一种实施例中，采用固件 DSP(数字信号处理器)方法来进行 GPS 处理。DSP 在 chipx2(2.046MHz)或 chipx8(8.184MHz)速率下接收 I 和 Q 取样，并将 4 位 I、Q 取样的短脉冲(snapshot)存储在内部 RAM 中。

在本示例性实施例中，DSP 产生 C/A 序列，执行旋转以去除频率多普勒，并且对于每一个卫星，在基站所提供的搜寻窗上进行相关。DSP 进行相干积分和非相干组合，并在必要时使 IQ 取样抽取器(decimator)旋转，以补偿编码多普勒。

为了节省计算和存储器，采用码片分辨率来进行初始搜寻，并且在最佳的一个(或多个)指数周围进行细搜寻以获得 1/8 码片(更高的)分辨率。系统时间是通过对硬件产生的 1ms 中断(从本机振荡器得到)进行计数来保持的。

另外，在本发明的一种实施例中，细搜寻是通过在各种 chipx8 偏移下，在一个码片的持续时间内对 chipx8 个取样(更高的分辨率)进行累积来执行的。将这些相关码用于累积值，而得到随特定的 chipx8 偏移而变化的相关值。这可以用 chipx8 分辨率确定编码偏移。

图 6 是描述用来在按照本发明的一种实施例执行的定位过程中校正本机振荡器误差所执行的步骤的流程图。在步骤 500，判断是否已经在近期校正了本机振荡器。如果没有，则从基站得到导频，并通过比较在步骤 502 处的导频定时和根据该误差所产生的校正信号，来确定本机振荡器的误差。

流程接着进行到步骤 504，这时，使校正信号固定在当前值上。在步骤 506，进入 GPS 方式，并用经校正的时钟来执行定位。一旦已经进行了定位，那么移动单元就在步骤 508 离开 GPS 方式。

图 7 描述的是按照本发明的一种实施例所构成的 DSP 接收机系统。DSP 用最少的附加硬件来执行整个搜寻操作。DSP 核心 308、调制解调器 306、接口单元 300、ROM 302 和存储器(RAM)304 是通过总线 306 耦合的。接口单元 300 从 RF 单元(未示出)接收 RF 取样，并将取样提供到 RAM 304。RF 取样可以以粗分辨率或细分辨率的方式存储起来。DSP 核心 308 用存储在 ROM 302 以及存储器 304 中的指令，处理存储在存储器中的取样。存储器 304 可以有“多组”，其中的某些组可以存储取样，而另一些组可以存储指令。调制解调器 700 在通常的方式下执行 CDMA 处理。

图 8 是在定位操作期间所执行的步骤的流程图。定位操作在接收到辅助消息的时候开始，并且 RF 系统在步骤 600 切换到 GPS 频率。当 RF 被切换而接收 GPS 时，频率跟踪环路是固定的。DSP 从电话微处理器接收辅助信息，并按照多普勒幅度对卫星进行分类。

在步骤 602，将粗搜寻数据存储在 DSP RAM 中。DSP 接收几百个微秒的输入数据以设置 Rx AGC。DSP 记录系统时间，并开始将 18ms 窗(DSP 存储极限)的 chipx2 IQ 数据存储在其内存 RAM 中。邻接的数据窗用来减弱编码多普勒的影响。

在存储了数据以后，在步骤 604 进行粗搜寻。DSP 开始进行粗(chipx2 分辨率)搜寻。对于每一个卫星来说，DSP 产生 C/A 码，根据频率多普勒使编码旋转，

并在基站所指定的搜寻窗上进行相关，而这些都是通过将 C/A 码多次用于所存储的粗搜寻数据而进行的。卫星在相同的 18ms 数据窗上进行处理，并且对于每一卫星，都得到一个超过某一阈值的最佳 chipx2 假设。尽管在本发明的一种实施例中使用的是 2ms 相干积分时间(有 9 个非相干积分)，但是也可以采用更长的相干积分时间(例如 18ms)，当然最好进行如下所述的某些调整。

在执行了粗搜寻以后，在步骤 606 进行细搜寻。在开始进行细搜寻以前，DSP 计算每一卫星的旋转 C/A 码。这使得 DSP 能够实时处理细搜寻。在进行细(chipx8 分辨率)搜寻时，卫星每次对不同的数据处理一次。

DSP 首先使抽取器(decimator)转向，以补偿给定卫星的编码多普勒。它还使 Rx AGC 值复位，同时在存储 chipx8 取样的 1ms 相干积分窗之前，等待下一个 1ms 的边界。

DSP 在 1ms 相干积分窗上处理 5 种邻接的 chipx8 分辨率假设，这里，中心假设是在粗搜寻中得到的最佳假设。在处理了下一个 1ms 窗口以后，将结果相干组合起来，并且在所有 Nn 次递归中非相干地将该 2ms 和组合起来。

对下一个卫星，对同一数据重复该步骤(从使抽取器转向开始)，直到所有的卫星已被处理完为止。如果 2 个卫星的编码多普勒在幅度上是相似的，那么就可以对同一数据对两个卫星进行处理以减少所需数据组的数目。在最坏的情况下，对于细搜寻，采用 8 组 1ms 的 2*Nn 数据窗。

最后，在步骤 608，将结果报告给微处理器，并在 DSP 中重新开始声码器处理，从而呼叫可以继续进行。DSP 将伪距报告给微处理器，由微处理器将这些伪距传送到基站。在微处理器再次将声码器程序码下载到 DSP 存储器内时，DSP 清除其数据存储器，并重新启动声码器。

图 9 是描述粗搜寻以后所执行的细搜寻的图。在粗搜寻中隔开了最佳 chipx2 相位以后，DSP 在该相位周围进行细搜寻，以获得 chipx8 的分辨率。

图中，在细搜寻中要比较的 5 个相位用一矩形圈了起来。最佳 chipx2 相位经再次估算，使得可以对同一组数据进行比较。这还使得粗搜寻和细搜寻可以采用不同的积分时间。由于每一卫星对于编码多普勒来说可以有不同的值，所以细搜寻对于每一卫星来说是分开进行的。

图 10 给出的是按照本发明一种实施例所进行的搜寻过程的等时线。在本发明的一种实施例中，整个处理(粗＋细)是在约 1.324 秒的时间里进行的，这会使呼叫中断，但在进行搜寻时仍会使呼叫继续进行。全部 1.324 秒的搜寻时间是一

个上限，这是因为这里假设 DSP 需要搜寻全部 8 个卫星，并且每一卫星有一个 68 码片的搜寻窗。然而，由于卫星轨道几何形状的原因，必须用足全部 1.324 秒的概率是很小的。

在开头的 18ms 期间，IQ 取样数据是在 GPS 频率下收集的。在周期 82 内，在内部进行粗搜寻，其时间可以持续到 1.13 秒，但在识别了卫星信号时，可能会早一点结束。在进行了粗搜寻以后，可以在周期 84 内计算 C/A 码，这需要 24ms。在周期 86 内，为编码多普勒调整转向值，并进一步调整 Rx AGC。在周期 88 内，对 IQ 数据取样进行细搜寻，并且在周期 86 中连续进行调整。使用 18ms 积分时间使得编码多普勒可以被忽略，这是因为所接收的 C/A 码相位将移位小于 1/16 个码片。最多可以对 8 个卫星进行最多 8 个序列的调整和细搜寻，这样就完成了整个定位过程。

另外，在本发明的某些实施例中，电话继续将反向链路帧发送到基站，同时进行定位过程。这些帧可以含有零个信息，使得基站可以容易地保持与用户单元同步，或者帧可以包含附加的信息，如功率控制命令或信息请求。这些帧的传送最好是当 GPS 取样不是在具有 RF 电路的时候得到的时候进行的，或者是如果具有充足的 RF 电路而得到 GPS 取样的时候。

尽管使用 18ms 积分时间避免了编码多普勒的影响，但在 50Hz 速率下，在 GPS 信号上进行数据传送会因 18ms 处理间隔内出现数据变化而产生问题(如上所述)。数据变化使得信号的相位发生偏移。对于每一卫星，会在不同的地方出现 50Hz 数据边界。每一卫星 50Hz 转换的相位通过从每一卫星到电话路径长度的变化而可以是随机的。

在最坏的情况时，如果在相干积分时间中点数据位出现反转，那么相干积分就会全部消除(wiped out)。因此，在本发明的另一种实施例中，基站必须将每一卫星的数据转换边界传送到电话(也如上所述)。最好将数据转换边界也包括在从基站发出的辅助消息中(如在表示每一卫星出现转换的毫秒时间间隔的一组 5 数据位消息中)。电话采用该边界将用于每一卫星的相干积分时间间隔分成 2 段，并判断在这两个时间区间内是加入还是减去相干积分和。因此，还通过包括每一 GPS 信号的数据边界，增加了定位过程的可靠性。

在本发明的示例性实施例中，频率不确定性产生损耗 Ec/Nt，它是随相干积分时间而增加的。例如，当不确定性是+/-100Hz 时，Ec/Nt 的损耗如表 I 所示的那样随相干积分时间的增加而快速增加。

Nc	Ec/Nt
1023(1ms)	0.14 dB
2046(2ms)	0.58 dB
4092(4ms)	2.42 dB
6138(6ms)	5.94 dB
8184(8ms)	12.6 dB

表 I

如上所述，在移动单元中，总有某些未知的本机振荡器的频移。就是这一未知的频移避免了进行更长相干去扩展和积分。如果可以减小未知频移的影响，更长的相干将改进处理过程。

在本发明的一种实施例中，通过将搜寻空间扩展成 2 维以包括频率搜寻来考虑未知的频移。对于每一种假设，进行几次频率搜寻，这里，每一次频率搜寻假设频移是一个已知值。通过使频移有一定的间隔，人们可以将频率不确定性减小到任一小的值，而其代价是增加了计算和存储。例如，如果采用 5 个频率假设，所得到搜寻空间如图 10 所示。

对于+/-100Hz 的频率不确定性，而这通常是移动单元典型的运行技术规范，该结构将最大的频移减少到 20Hz(一种假设必须在实际频移 20Hz 内)。在 20ms 的相干积分时间的情况下，具有 20Hz 频移的 Ec/Nt 的损耗是 2.42dB。通过将频率假设数翻倍成 10，频率不确定性可以减小到 10Hz，这产生.58dB 的 Ec/Nt 损耗。然而，加入另外的假设加宽了搜寻空间，这增加了计算和存储要求。

本发明的一种实施例通过使频移与频率多普勒相结合，并计算每一频率假设新的旋转的 PN 码来计算频率假设。然而，这使得频率假设数在整个计算中取某一倍数：5 个频率假设意味着 5 倍多的计算。

另外，由于与频率多普勒相比这一频率不确定性很小，旋转相位可以被看作是本发明另一实施例中在 1ms 时间间隔中是不变的(80Hz 假设为周期的 8%)。所以通过将相干积分时间间隔分成 1ms 子区间，使子区间的积分和旋转，从而将计算频率搜寻所需的增加的计算减少三个数量级。结果是可以执行更长的相干去扩展，并使性能改进。

图 12 是按照更长相干去扩展方法构成的接收机的方框图。第一组乘法器 50 通过使 IQ 取样与旋转的 C/A 码相关来补偿频率多普勒。这等效于在与未改进 C/A

码相关之前使 IQ 取样旋转。由于频率多普勒可以多达 4500Hz，对每一码片进行旋转。在用累加器 52 在 1ms 时间间隔(1023 个码片)内进行了相干积分以后，第二组乘法器 54 使 1ms 积分和(Σ_I 和 Σ_Q)旋转，以实现频率假设。随后在整个相干积分时间间隔内将旋转和相加。

回忆一下，仅对 1023 个码片计算频率多普勒旋转，以节省存储和计算。对于比 1ms 长的相干积分时间，每一相干积分和乘以相移，以使旋转的相位随时间是连续的。为了在数学上给出这一点，采用频率多普勒旋转的 1ms 相干积分和可以表述成：

$S_1 = \sum_{n=1}^{1023}[I(n) + jQ(n)]c(n)e^{-jw_d nT_c}$，这里，$\Sigma_I = \mathrm{Re}\{S_1\}$，并且 $\Sigma_Q = \mathrm{Im}\{S_1\}$

这里，I(n) 和 Q(n) 分别是在 I 和 Q 信道上接收的输入取样，c(n) 是未经旋转的 C/A 码，w_d 是频率多普勒，而 T_c 是码片时间间隔(.9775us)。2ms 相干积分和可以表述成：

$$
\begin{aligned}
S(2ms) &= \sum_{n=1}^{2046}[I(n) + jQ(n)]c(n)e^{-jw_d nT_c} \\
&= \sum_{n=1}^{1023}[I(n) + jQ(n)]c(n)e^{-jw_d nT_c} + e^{-jw_d(1023)T_c}\sum_{n=1}^{1023}[I(n+1023) + jQ(n+1023)]c(n)e^{-jw_d nT_c} \\
&= S_1 + e^{-jw_d(1023)T_c}S_2
\end{aligned}
$$

这里，S_1 是第一 1ms 积分和，而 S_2 是第二 1ms 积分和，第二积分和是用相同的旋转 C/A 值来计算的，并且 C/A 值用来计算 S_1。$e^{-jwd(1023)Tc}$ 项是补偿使用相同的旋转值的相移。与此相似，一个 3ms 的相干积分和可以表述成：

$S(3ms) = S_1 + e^{-jw_d(1023)T_c}S_2 + e^{-jw_d(2046)T_c}S_3$

所以，为了延长积分时间，并且同时使用相同的 1023 元旋转的 C/A 序列，(n+1)1ms 的积分和应当在被加到整个和内之前乘以 $e^{-jwdn(1ms)}$。由于这是 1ms 积分和的旋转，所以，我们可以将该运算与频率搜寻组合在一起，以避免进行 2 次旋转。即，由于

$e^{-jw_d n(1ms)}e^{-jw_d n(1ms)} = e^{-j(w_d+w_h)n(1ms)}$

我们可以将第(n+1)个 1ms 的积分和乘以 $e^{-j(wd+wh)n(1ms)}$，以搜寻频率假设，并考虑频率多普勒相移。

注意，频率搜寻可以在获得了一个卫星以后而减少，这是因为频率不确定性

是不依赖于卫星的。如果要求有更长的相干积分，那么就可以进行更加精细的频率搜寻。

在本发明的示例性实施例中，细搜寻与粗搜寻相似，但有两个区别。第一，积分时间间隔总是被相干相加在一起，而不是非相干地取平方和相加。第二，去掉频率不确定性的旋转(在粗搜寻后应当是已知的)与频率多普勒相移组合起来，并用来在将它们相加之前使 1ms 的相干积分时间间隔旋转。

在本发明的另一种实施例中，在比 18ms 更长的积分时间里对 chipx2 数据的相干积分窗进行积分。该实施例在具有附加存储器的时候是有用的。对于比 18ms 更长的相干积分，50Hz 数据边界被当作与具有更短积分周期的情况一样对待。基站给出边界是在哪里用于每一卫星的，并且 DSP 判断是否在其计算的和中加入或减去了 20 个 1ms 的相干积分时间间隔的和。

然而，由于频率不确定性和积分时间常数的乘积会影响 Ec/Nt 的损耗，所以对于长相干积分时间，必须将频率不确定性减小到很小的水平上。由于具有 20Hz 的频率不确定性使 20ms 的积分产生的 Ec/Nt 损耗是 2.42dB，所以在 400ms 的积分时间里保持相同的损耗要求将频率不确定性减小到 1Hz。为了解决这一问题，以分阶段的方法将频率不确定性减小到 1Hz。例如，第一次频率搜寻将不确定性从 100Hz 减小到 20Hz，第二次搜寻将不确定性减小到 4Hz，而第三次搜寻使不确定性减小到 1Hz。频率搜寻还将补偿从基站获得的频率多普勒中的误差。

另外，由于每一卫星的编码多普勒是不同的，所以，为了进行更长时间的积分，在较长的积分时间里对同一数据搜寻具有相似多普勒的卫星。DSP 计算要花费多长的时间来使 1/16 的码片延迟(slip)，或者使抽取器在收集相干积分数据窗时使其旋转(slew)。另外，在本实施例中采用了多个数据窗。

至此，我们已经描述了无线通信系统中进行定位的方法和装置。前文中对较佳实施例的描述可以使本领域中的普通技术人员能够使用和制造本发明。很明显，对于本领域中的普通技术人员来说，还可以对这些实施例作各种修改，并且无需发明人的帮助，可以将所揭示的基本原理应用于其他的实施例。所以，本发明并非仅限于这里所揭示的实施例，应当从最宽的范围来理解说明书和权利要求书中所揭示的本发明的原理和特征。

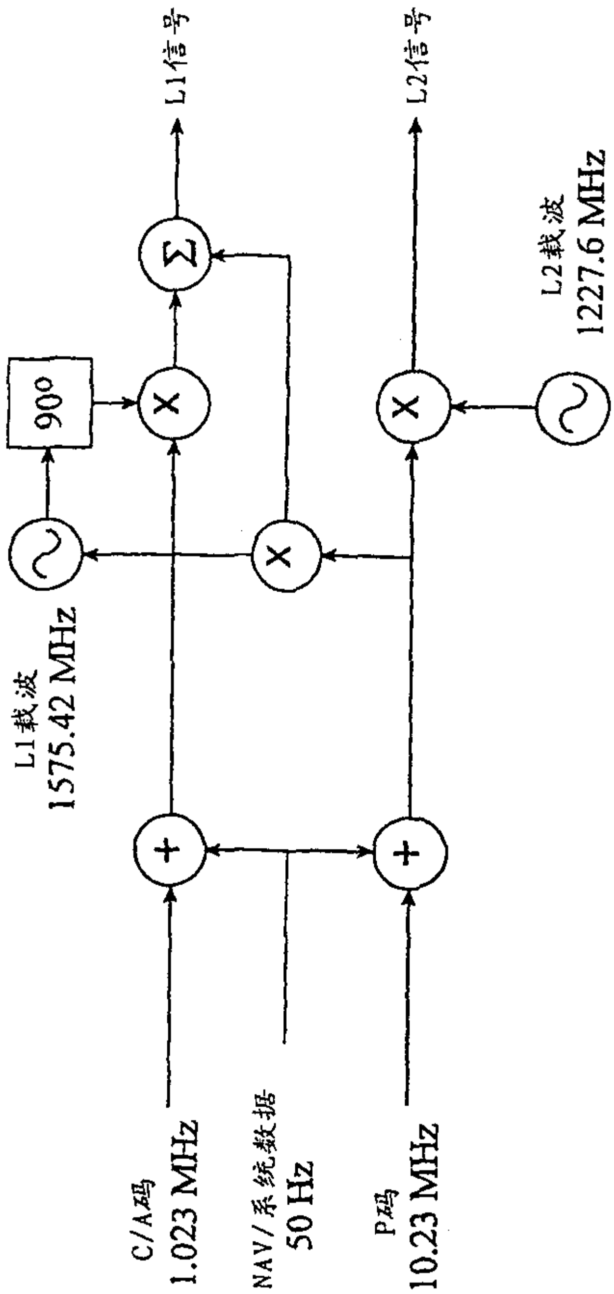

L1信号
L2信号
Σ
90°
L1载波
1575.42 MHz
L2载波
1227.6 MHz
C/A码
1.023 MHz
NAV/系统数据
50 Hz
P码
10.23 MHz

图 1

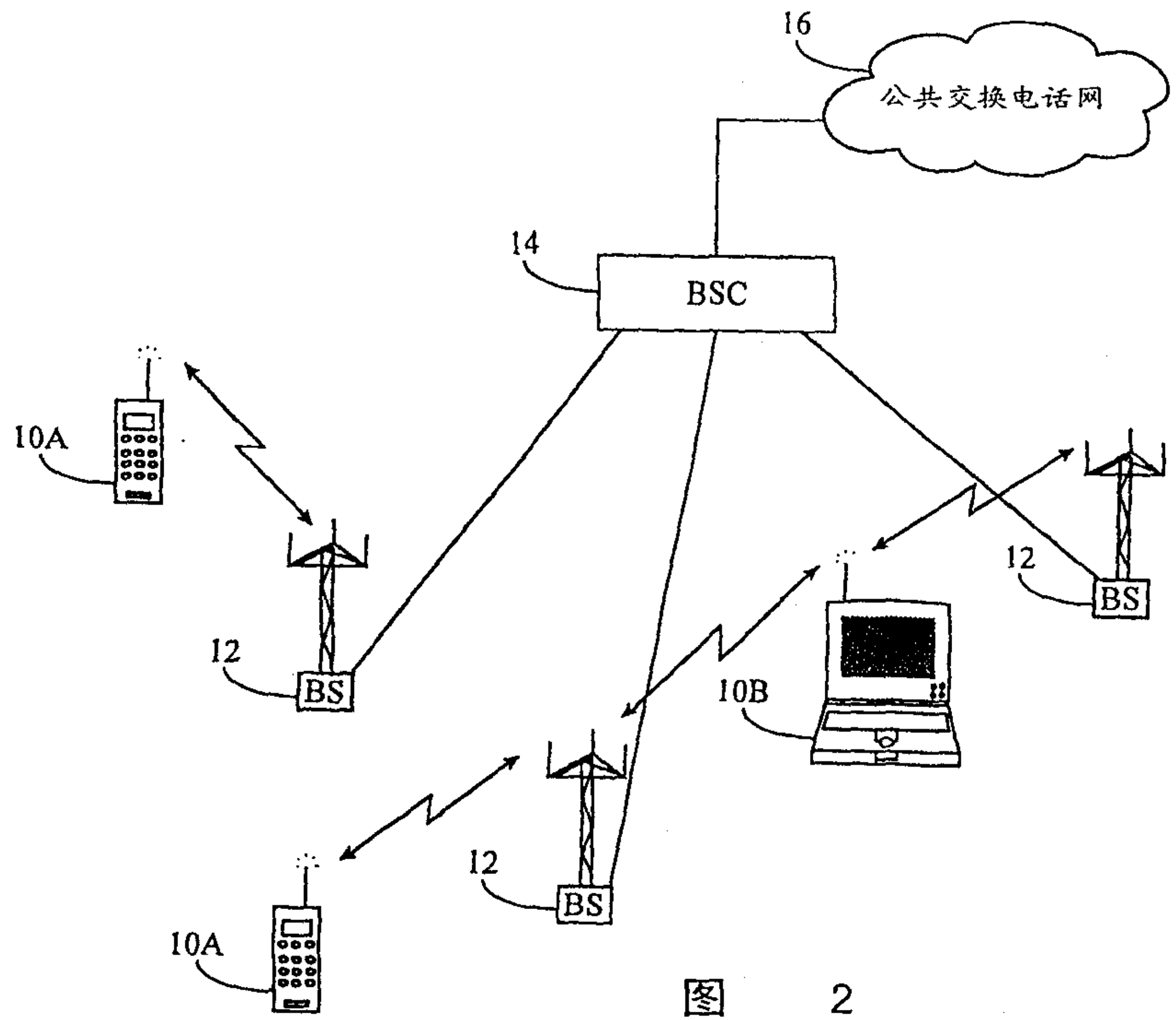


图 2

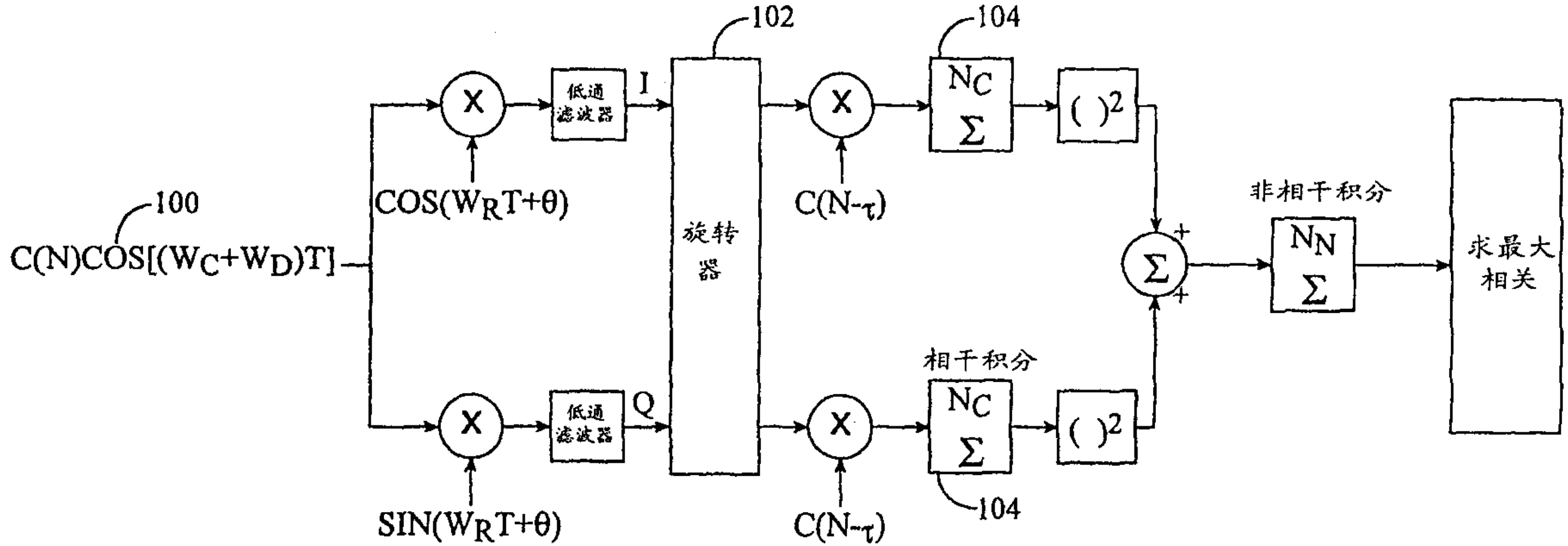

100
C(N)COS[(WC+WD)T]
COS(WRT+θ)
SIN(WRT+θ)
X
X
低通
滤波器
低通
滤波器
I
Q
102
旋转
器
X
X
C(N-τ)
C(N-τ)
104
104
相干积分
NC
Σ
NC
Σ
( )2
( )2
Σ
+
+
非相干积分
NN
Σ
求最大
相关

图 3

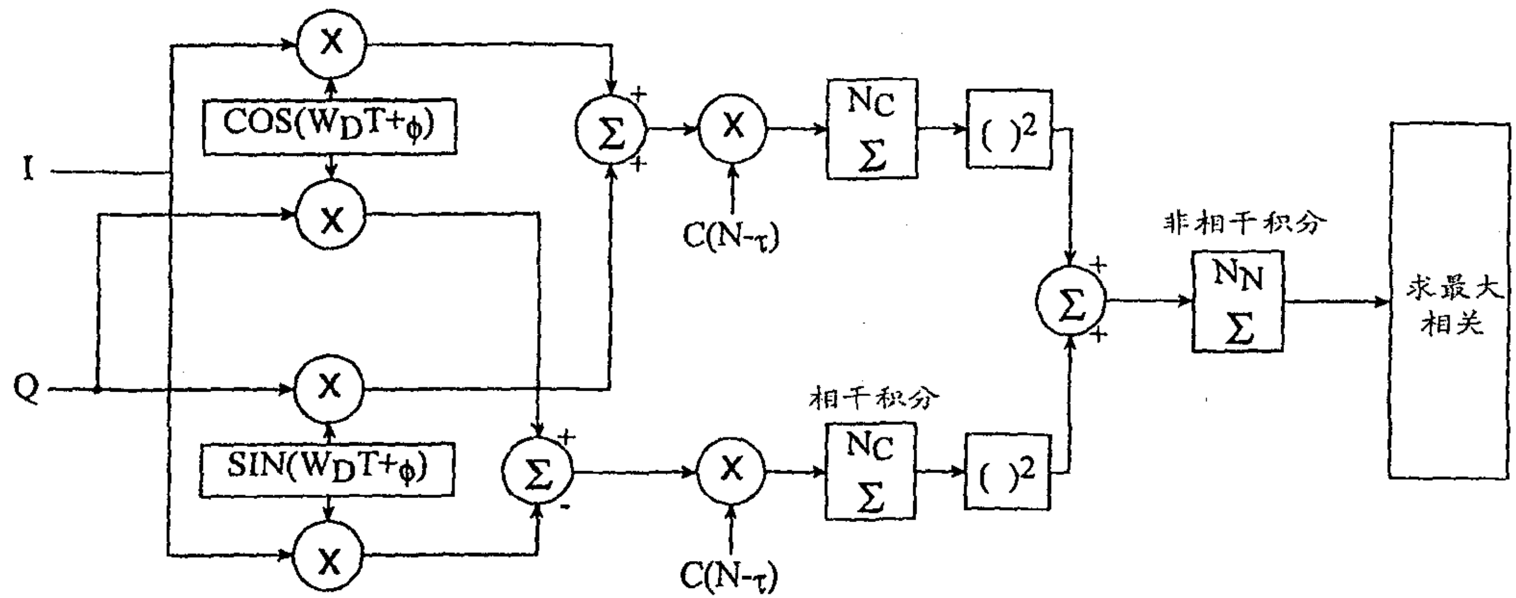


图 4

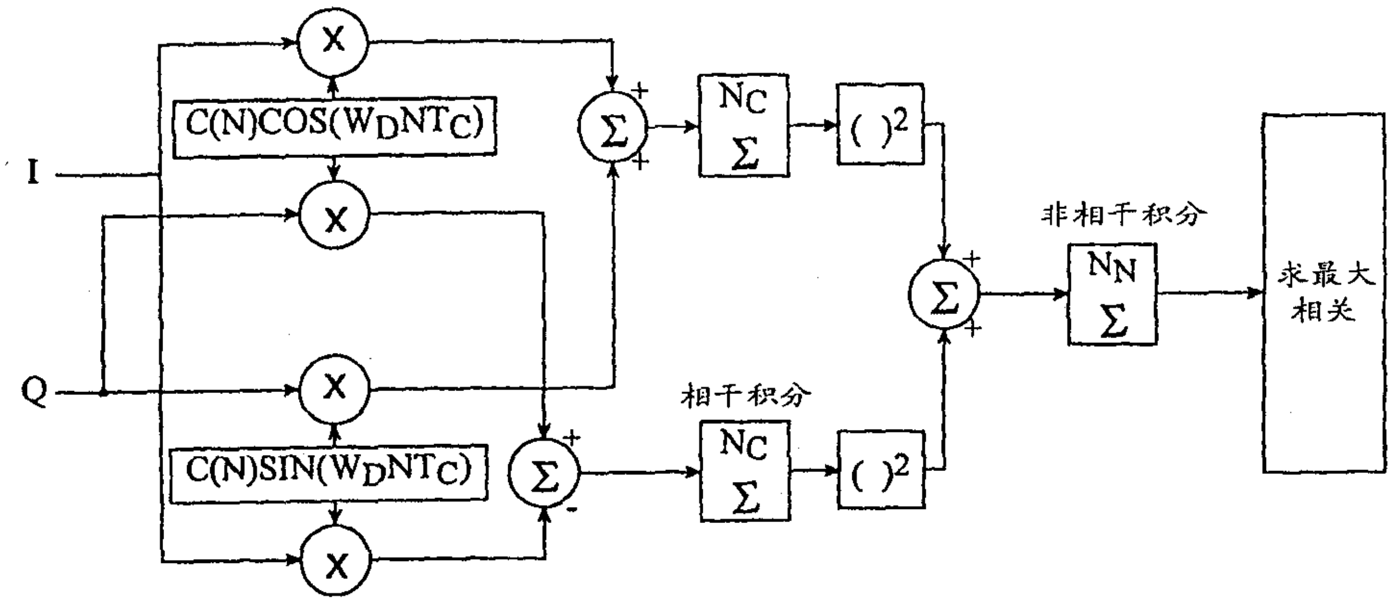


图 5

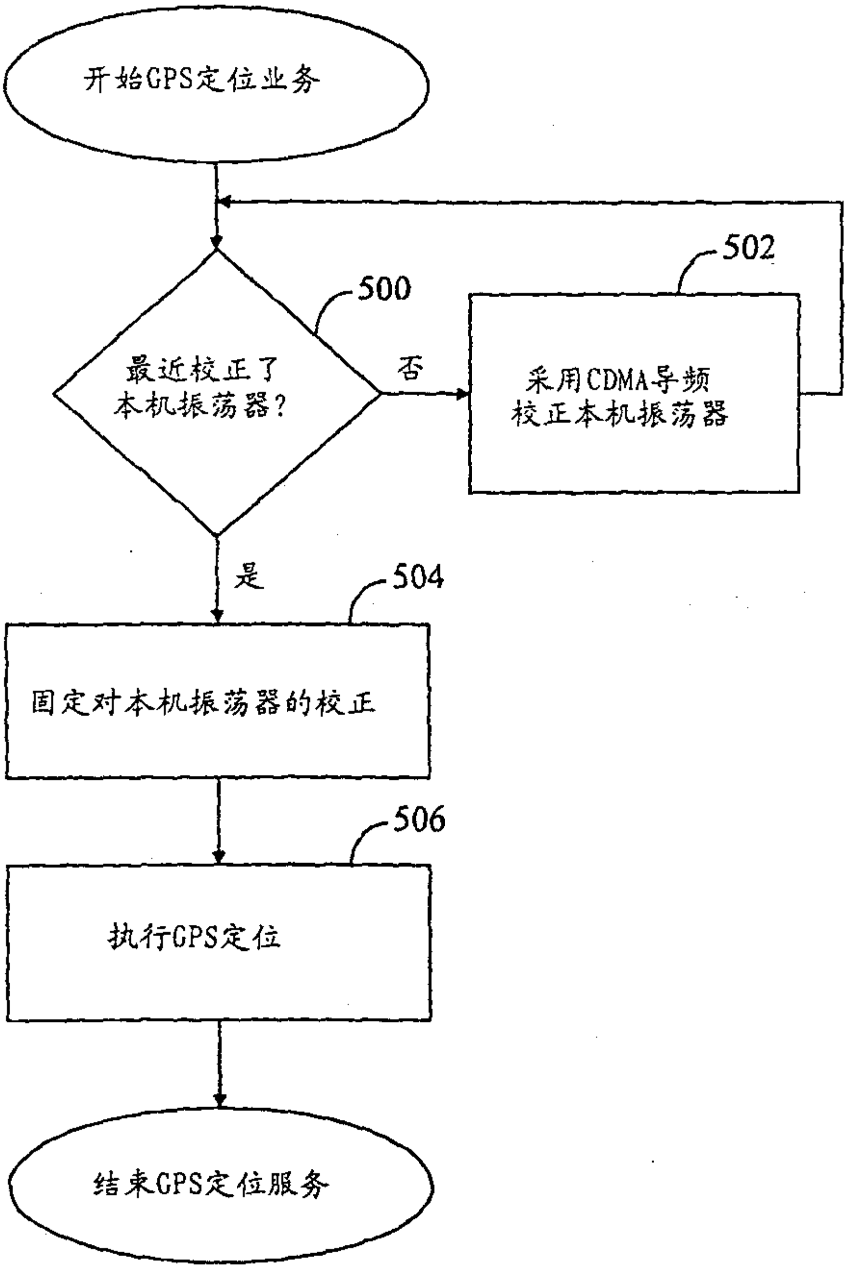

开始GPS定位业务
500
最近校正了
本机振荡器？
否
502
采用CDMA导频
校正本机振荡器
是
504
固定对本机振荡器的校正
506
执行GPS定位
结束GPS定位服务

图 6

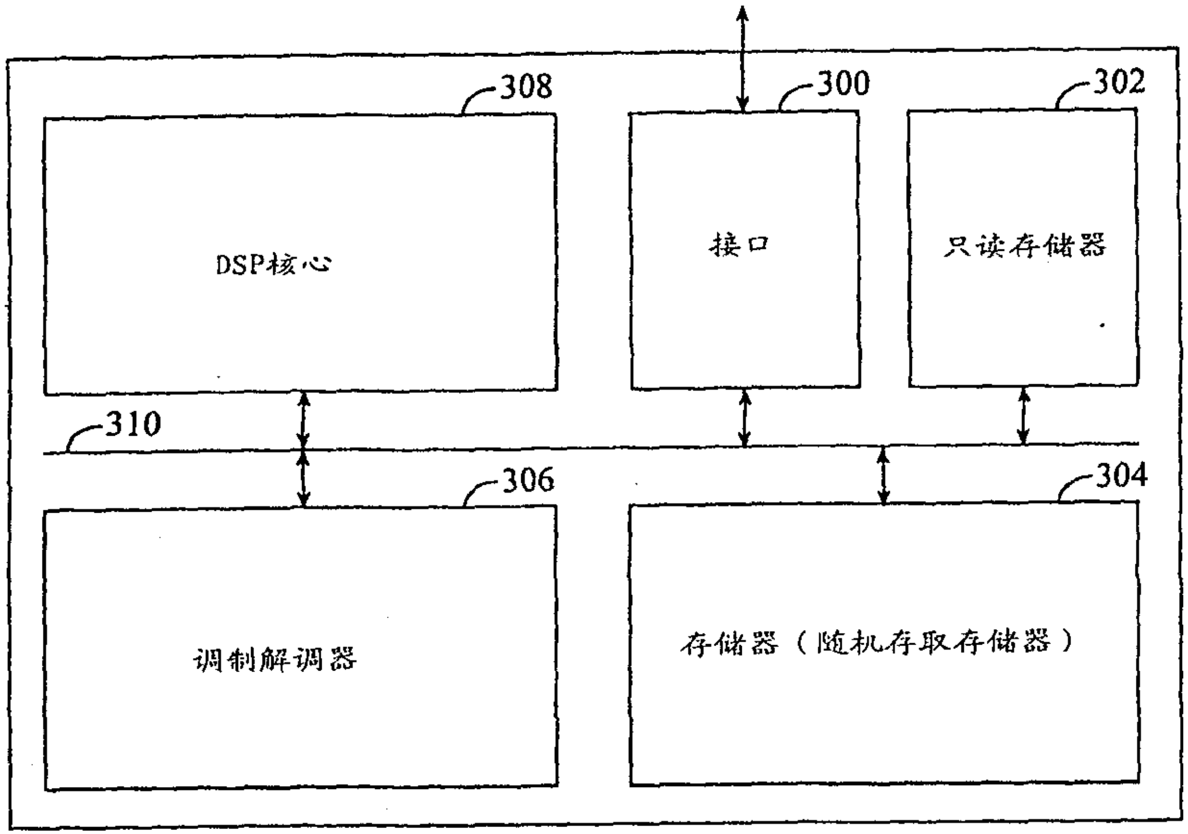


图 7

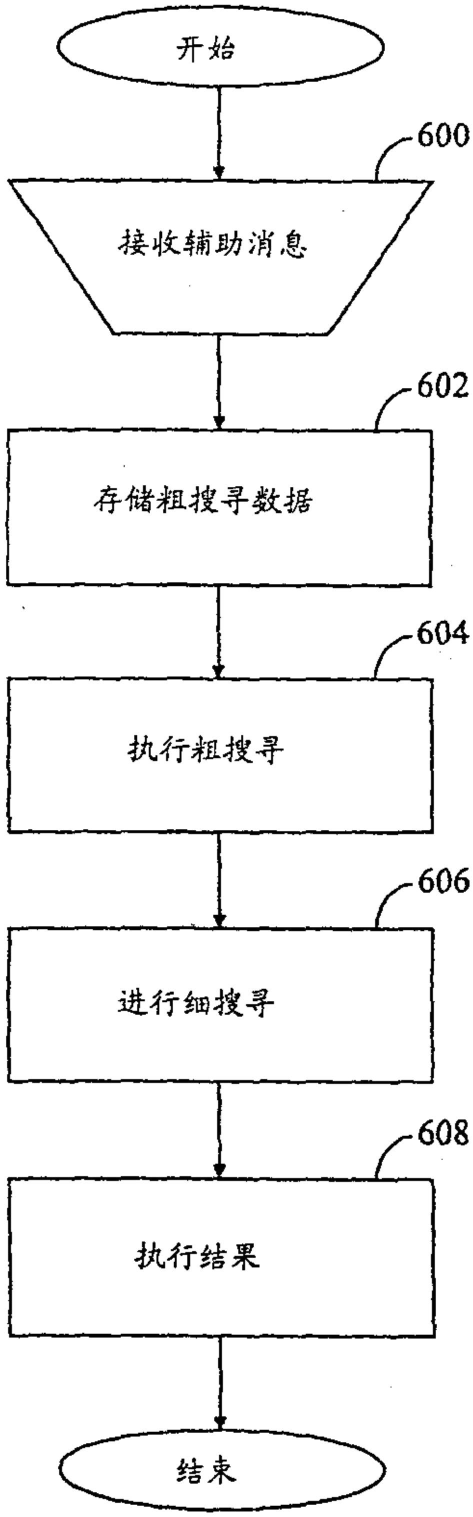


图 8

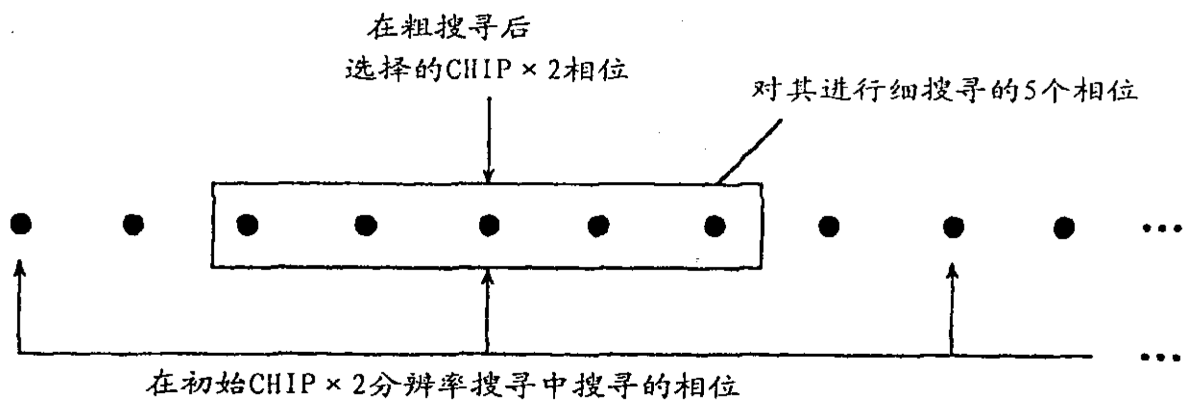


图 9

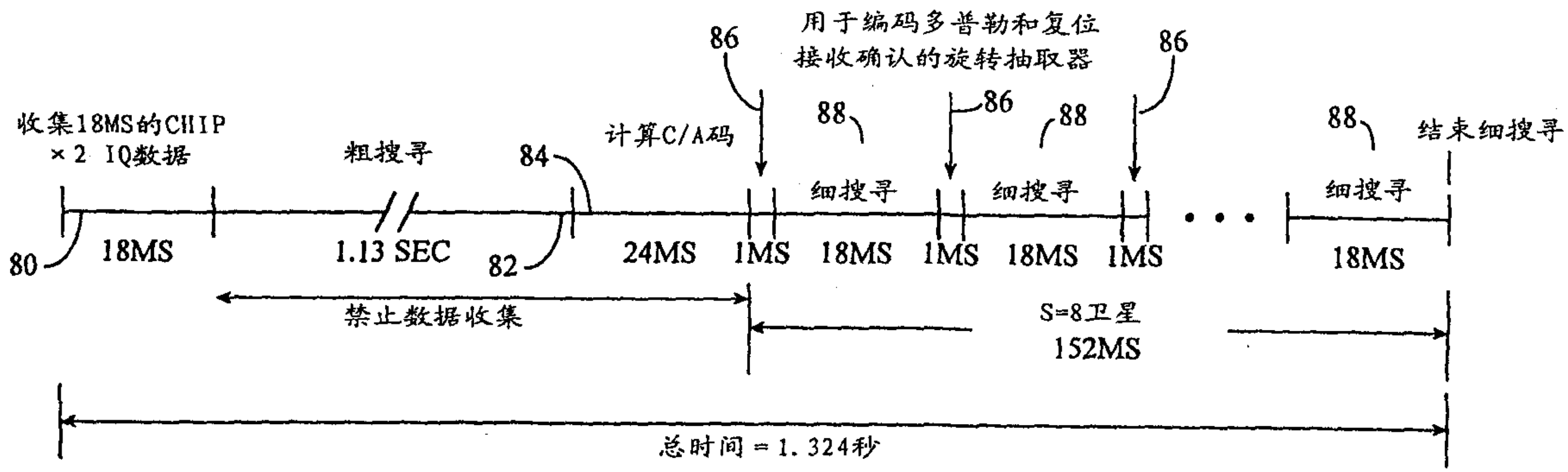

收集18MS的CHIP
×2 IQ数据
粗搜寻
计算C/A码
用于编码多普勒和复位
接收确认的旋转抽取器
细搜寻
细搜寻
细搜寻
结束细搜寻
80
82
84
86
86
86
88
88
88
18MS
1.13 SEC
24MS
1MS
18MS
1MS
18MS
1MS
18MS
禁止数据收集
S=8卫星
152MS
总时间=1.324秒

图 10

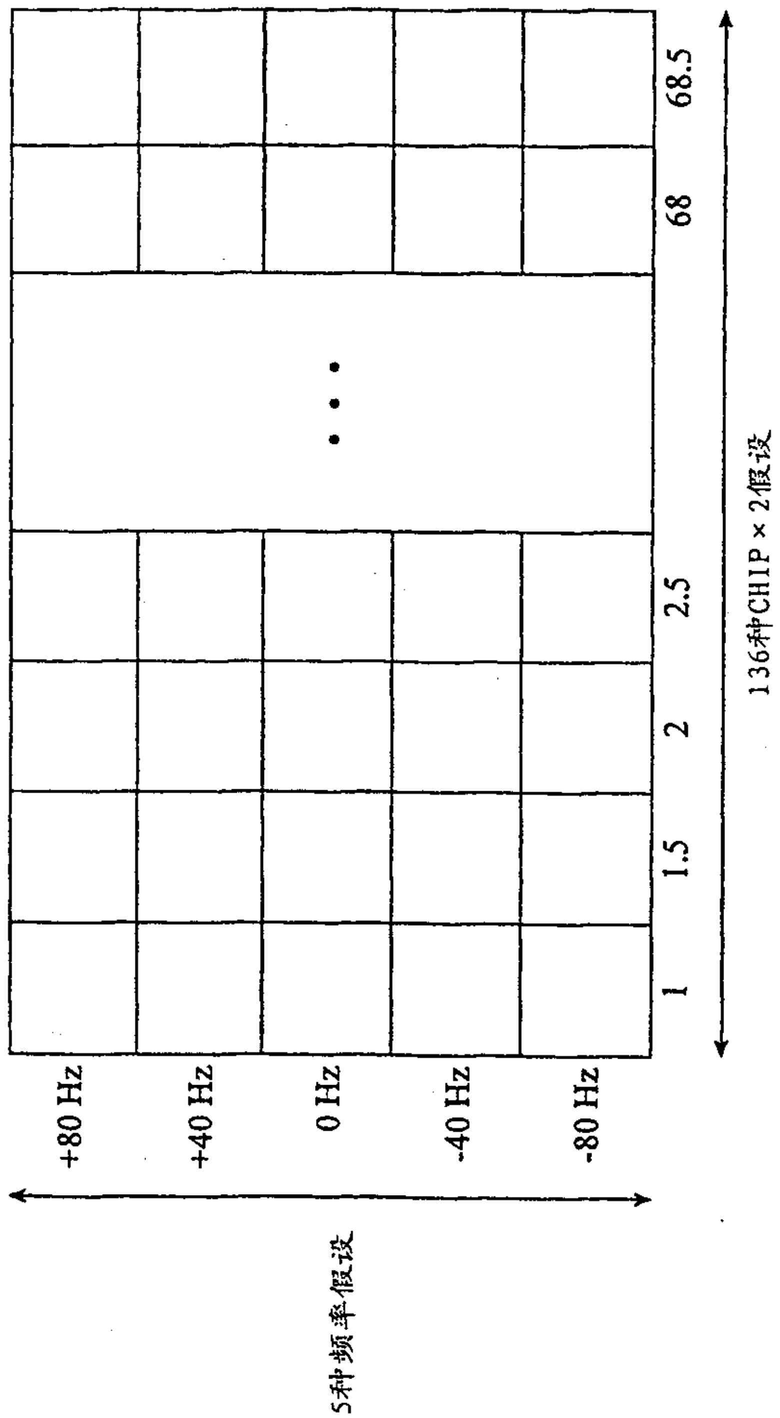


图 11

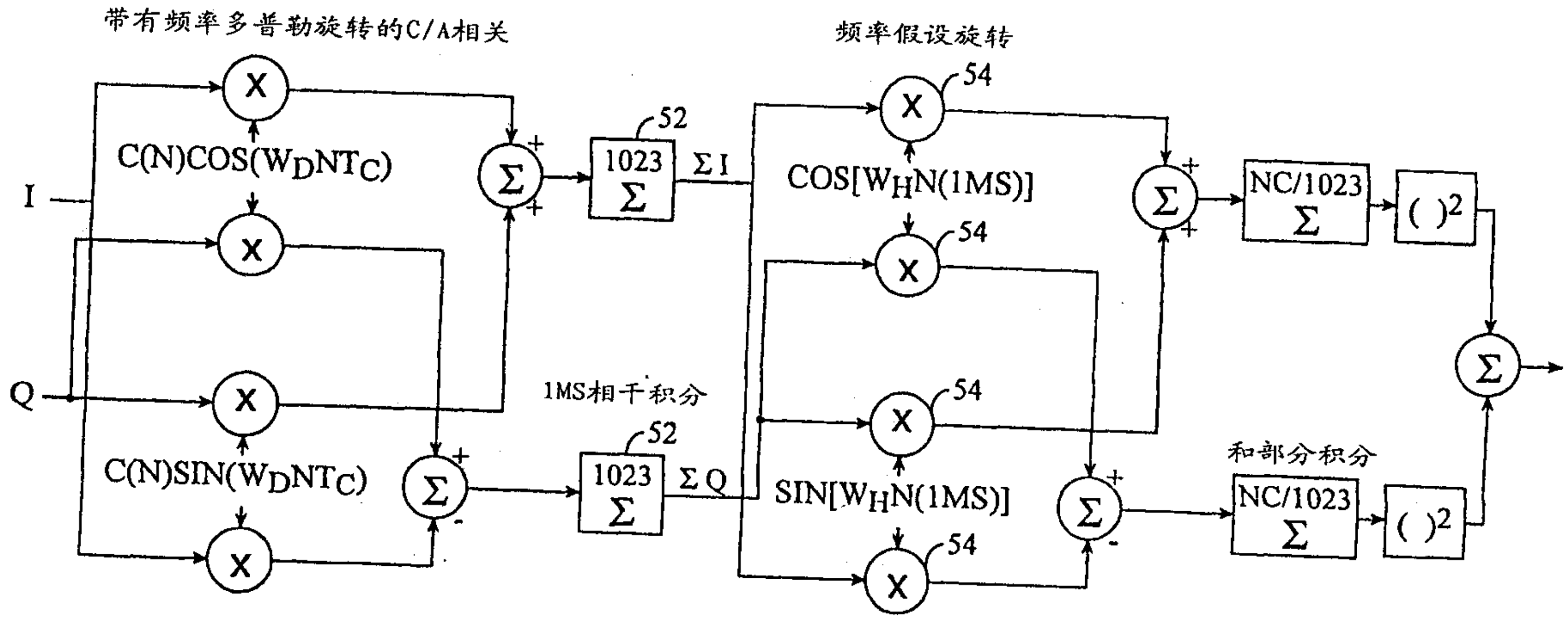

带有频率多普勒旋转的C/A相关
频率假设旋转
1MS相干积分
和部分积分
I
Q
C(N)COS(WDNTC)
C(N)SIN(WDNTC)
COS[WHN(1MS)]
SIN[WHN(1MS)]
1023
ΣI
ΣQ
NC/1023
( )2
52
54

图　12