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(54) CONTROL CHANNEL ACQUISITION

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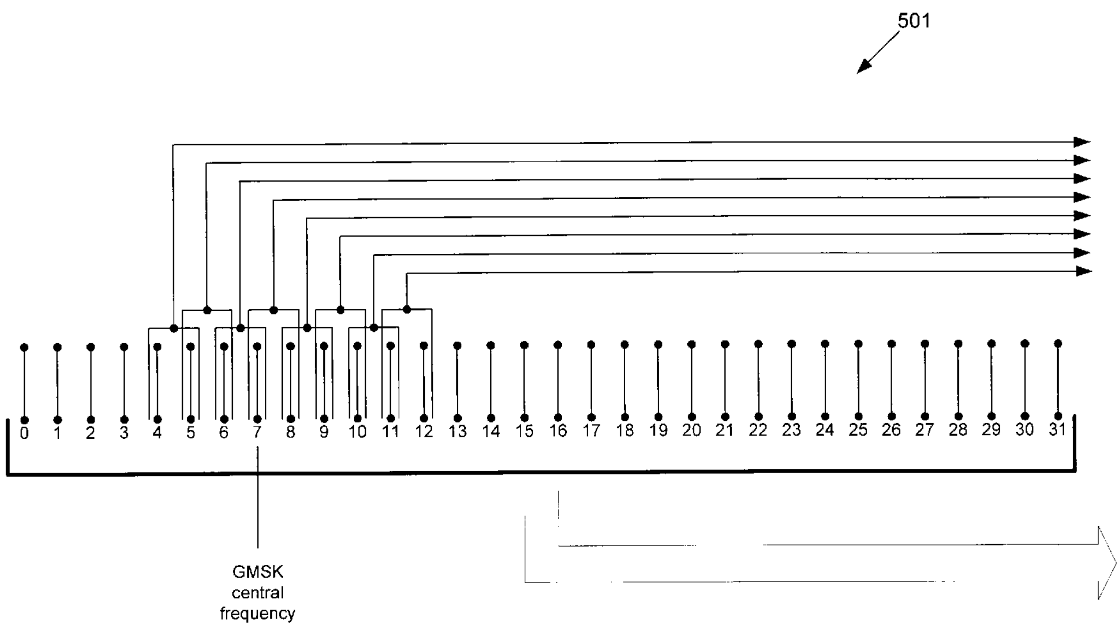
(57) **ABSTRACT**

Disclosed are various embodiments of control channel acquisition systems and methods. A baseband processor in communication with the RF transceiver performs an initial detection of a carrier frequency based on GMSK symbols in the FCCH. The initial detection is refined and verified by passing a signal through a mathematical filter and comparing an energy of the filtered signal to a threshold.



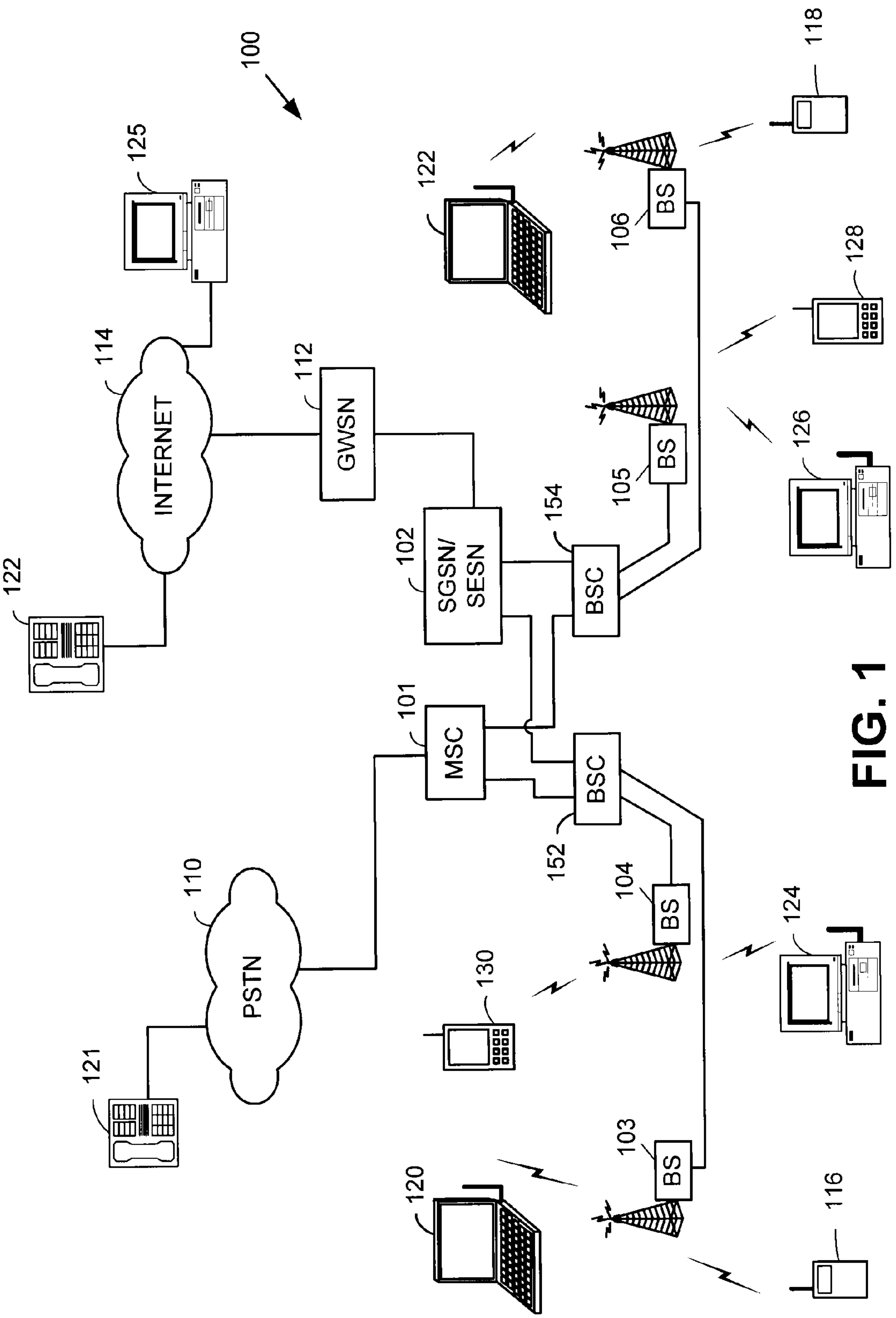

100
125
114
INTERNET
122
112
GWSN
102
SGSN/
SESN
154
BSC
105
BS
106
BS
122
118
128
126
101
MSC
152
BSC
104
BS
110
PSTN
121
130
124
103
BS
120
116

FIG. 1

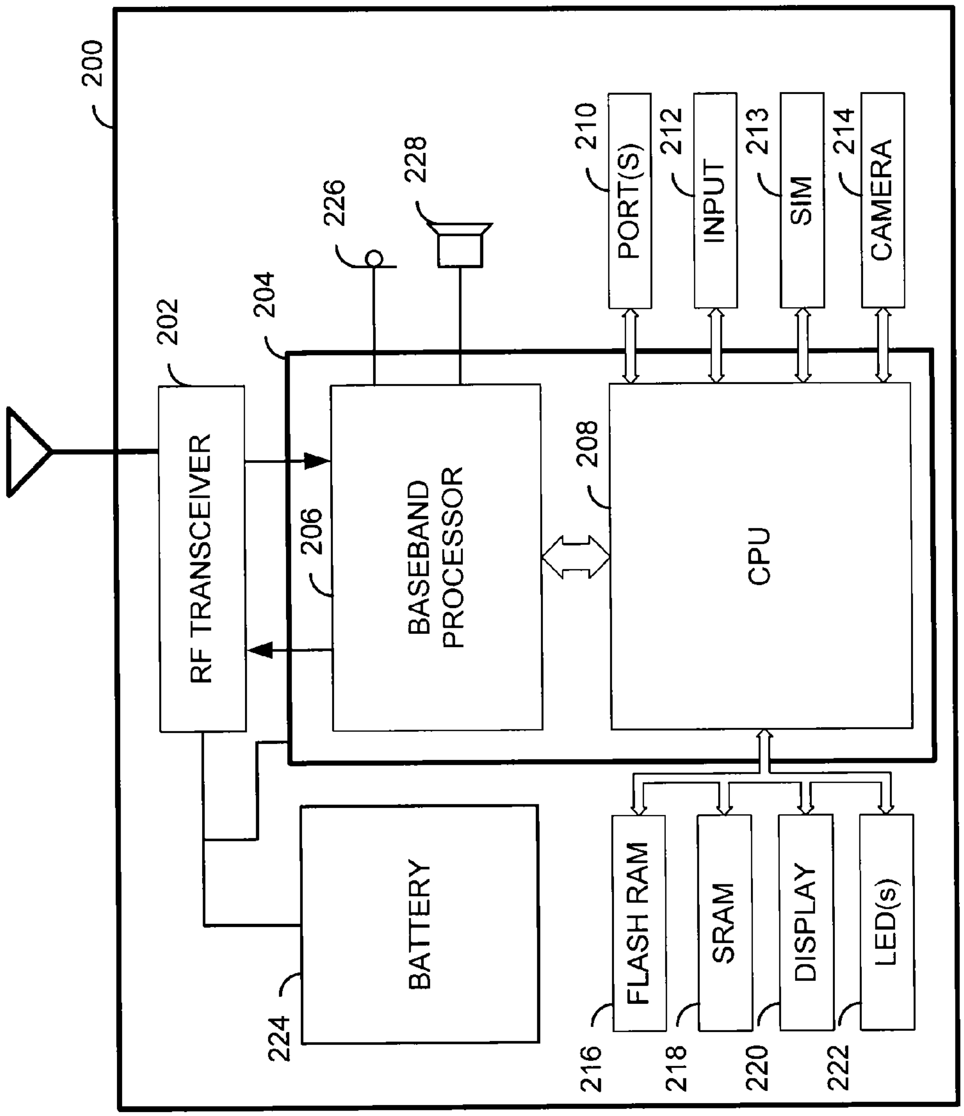

200
202
RF TRANSCEIVER
204
206
BASEBAND PROCESSOR
208
CPU
226
228
210
PORT(S)
212
INPUT
213
SIM
214
CAMERA
224
BATTERY
216
FLASH RAM
218
SRAM
220
DISPLAY
222
LED(s)

FIG. 2

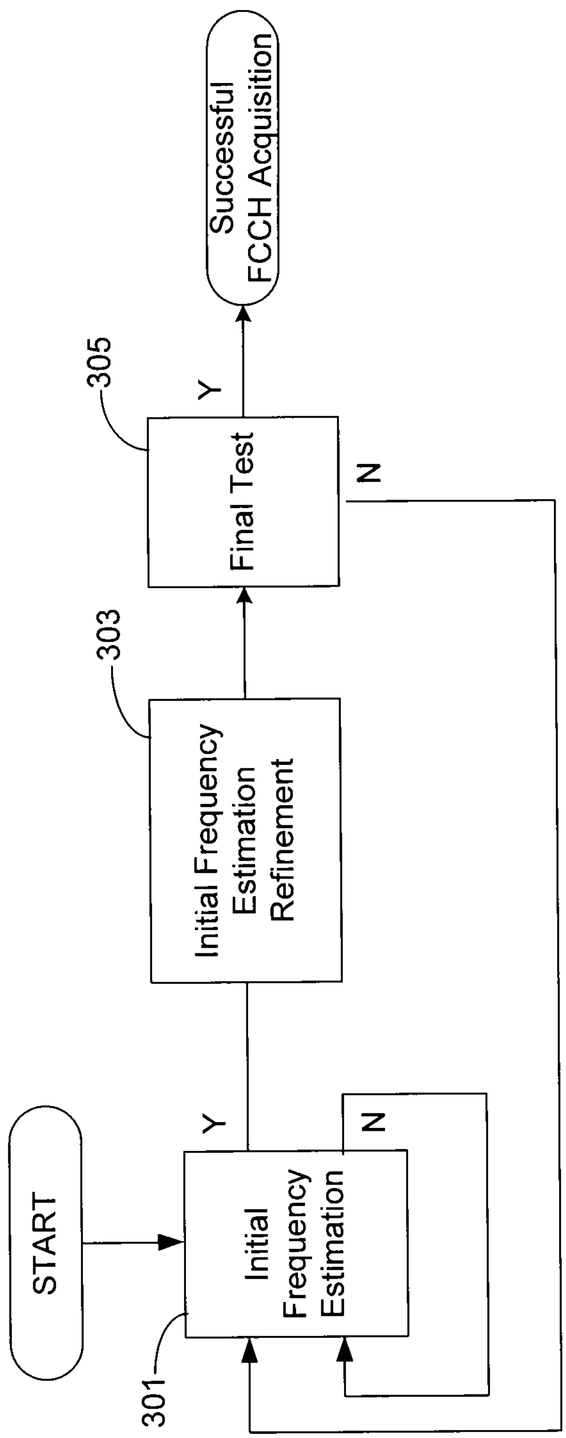

START
Initial Frequency Estimation
301
Y
N
Initial Frequency Estimation Refinement
303
Final Test
305
Y
N
Successful FCCH Acquisition

FIG. 3

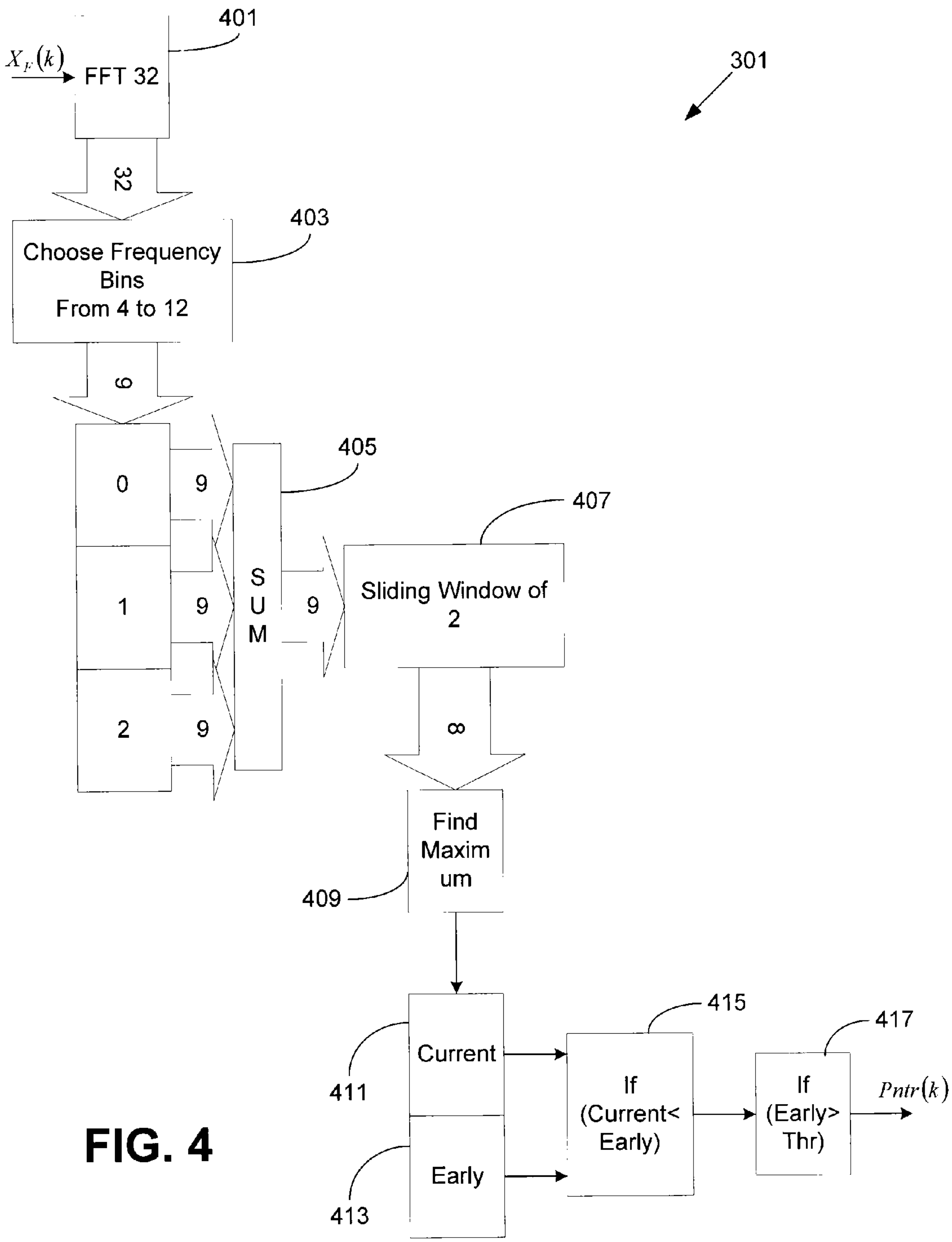

$X_F(k)$
FFT 32
401
301
32
Choose Frequency Bins From 4 to 12
403
9
0
1
2
9
9
9
S U M
405
9
Sliding Window of 2
407
8
Find Maximum
409
Current
411
Early
413
If (Current< Early)
415
If (Early> Thr)
417
$Pntr(k)$

FIG. 4

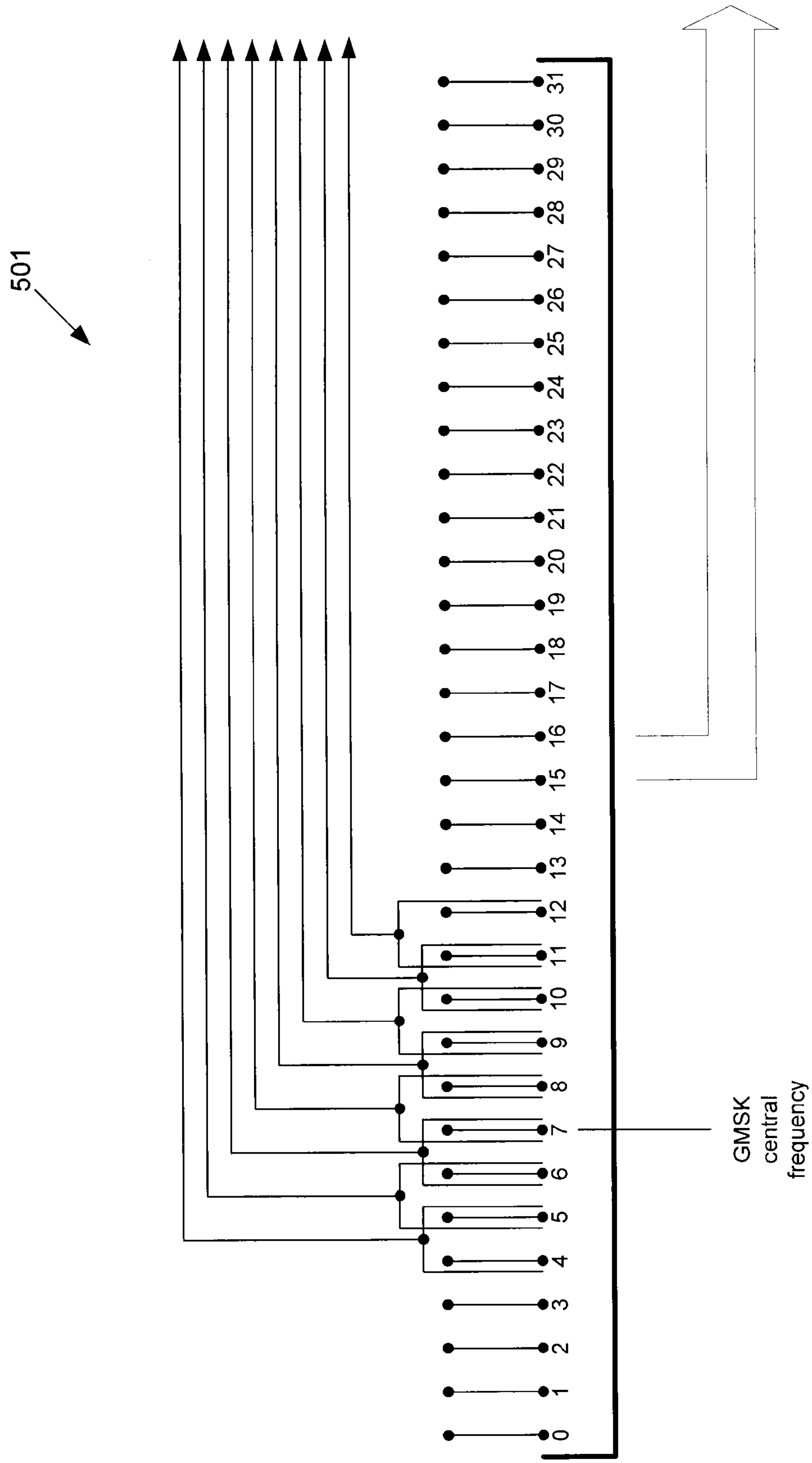

501
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
GMSK
central
frequency

FIG. 5

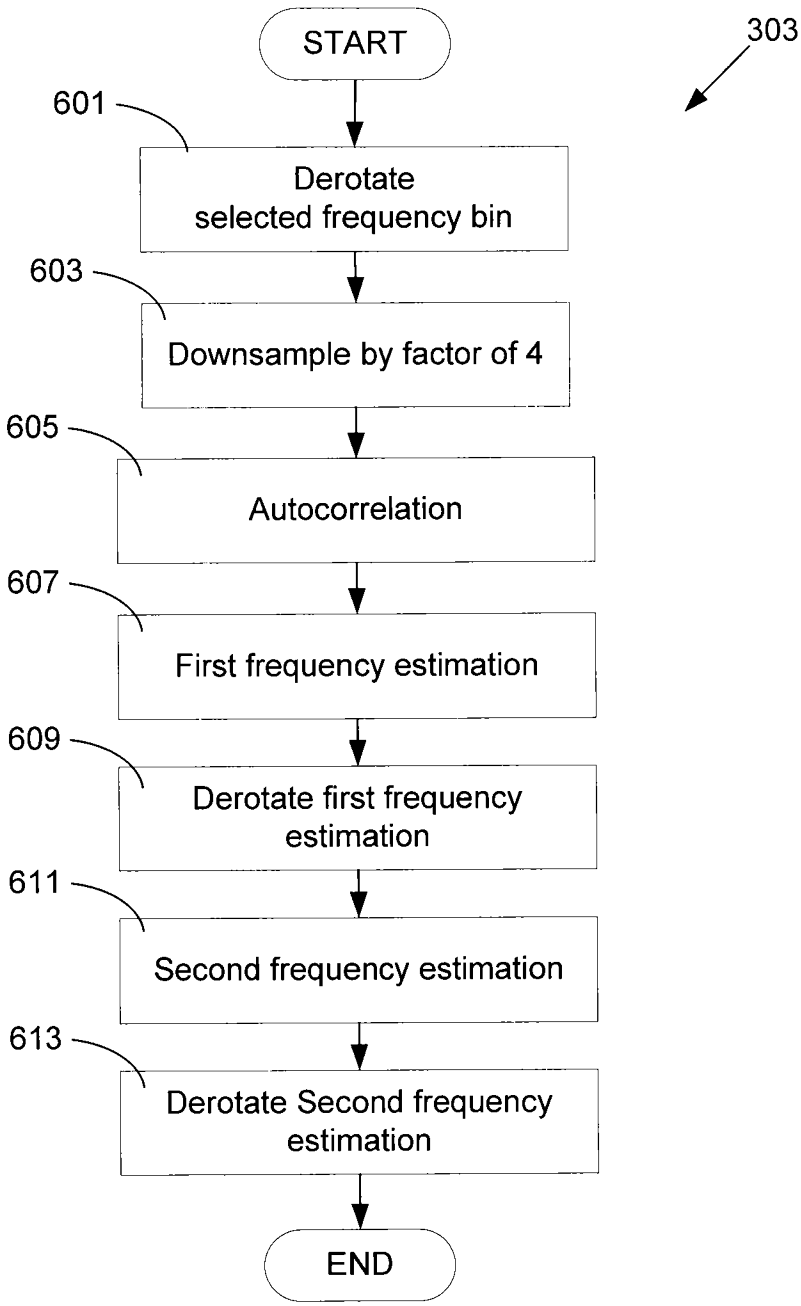

START
303
601
Derotate selected frequency bin
603
Downsample by factor of 4
605
Autocorrelation
607
First frequency estimation
609
Derotate first frequency estimation
611
Second frequency estimation
613
Derotate Second frequency estimation
END

FIG. 6

CONTROL CHANNEL ACQUISITION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to co-pending U.S. provisional application Ser. No. 61/565,864, entitled "Cellular Baseband Processing," filed Dec. 1, 2011, which is incorporated herein by reference in its entirety. This application also claims priority to co-pending U.S. Provisional application Ser. No. 61/568,868, entitled "Cellular Baseband Processing," filed Dec. 9, 2011, which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] Cellular wireless communication systems support wireless communication services in many populated areas of the world. While cellular wireless communication systems were initially constructed to service voice communications, they are now called upon to support data communications as well. The demand for data communication services has exploded with the acceptance and widespread use of the Internet. While data communications have historically been serviced via wired connections, cellular wireless users now demand that their wireless units also support data communications. Many wireless subscribers now expect to be able to "surf" the Internet, access their email, and perform other data communication activities using their cellular phones, wireless personal data assistants, wirelessly linked notebook computers, and/or other wireless devices. The demand for wireless communication system data communications will only increase with time. Thus, cellular wireless communication systems are currently being created/modified to service these burgeoning data communication demands.

[0003] Cellular wireless networks include a "network infrastructure" that wirelessly communicates with wireless terminals and/or mobile devices within a respective service coverage area. The network infrastructure typically includes a plurality of base stations dispersed throughout the service coverage area, each of which supports wireless communications within a respective cell (or set of sectors). The base stations couple to base station controllers (BSCs), with each BSC serving a plurality of base stations. Each BSC couples to a mobile switching center (MSC). Each BSC also typically directly or indirectly couples to the Internet.

[0004] In operation, each base station communicates with a plurality of wireless terminals operating in its cell/sectors. A BSC coupled to the base station routes voice communications between the MSC and a serving base station. The MSC routes voice communications to another MSC or to the PSTN. Typically, BSCs route data communications between a servicing base station and a packet data network that may include and/or couple to the Internet. Transmissions from base stations to wireless terminals are referred to as "forward link" transmissions while transmissions from wireless terminals to base stations are referred to as "reverse link" transmissions. The volume of data transmitted on the forward link typically exceeds the volume of data transmitted on the reverse link. Such is the case because data users typically issue commands to request data from data sources, e.g., web servers, and the web servers provide the data to the wireless terminals.

[0005] Wireless links between base stations and their serviced wireless terminals typically operate according to one (or more) of a plurality of operating standards. These operating standards define the manner in which the wireless link may be allocated, setup, serviced and torn down. One popular cellular standard is the Global System for Mobile telecommunications (GSM) standard. The GSM standard, or simply GSM, is predominant in Europe and is in use around the globe. While GSM originally serviced only voice communications, it has been modified to also service data communications. In GSM, wireless terminals are informed of the need to service incoming communications via pages from base stations to the wireless terminals. GSM General Packet Radio Service (GPRS) operations and the Enhanced Data rates for GSM (or Global) Evolution (EDGE) operations coexist with GSM by sharing the channel bandwidth, slot structure, and slot timing of the GSM standard. GPRS operations and EDGE operations may also serve as migration paths for other standards as well, e.g., IS-136 and Pacific Digital Cellular (PDC).

[0006] According to the GSM standard, a BSC transmits various signaling channels that facilitate communication with a wireless terminal, or mobile device. For example, Broadcast Channels can include a Broadcast Control Channel (BCCH), a Frequency Correction Channel (FCCH), and other channels as defined by the standard. These various channels facilitate the BSC and a mobile device to establish communications with one another. For example, the BCCH allows the BSC to broadcast information about the identity of a network to which it corresponds, such as a Mobile Network Code (MNC), Location Area Code (LAC), and other information. The FCCH includes an FCCH burst, which is an all-zero or all-one sequence that produces a fixed GMSK tone, which enables a mobile device to lock its local oscillator to the BSC clock.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Many aspects of the invention can be better understood with reference to the following drawings. The components in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the present invention. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views.

[0008] FIG. **1** is a system diagram illustrating a portion of a wireless communication system that supports mobile devices and/or wireless terminals operating according to the present invention.

[0009] FIG. **2** is a block diagram functionally illustrating a mobile device according to an embodiment of the disclosure.

[0010] FIG. **3** is a drawing illustrating a state machine executed by the baseband processor to determine a carrier frequency from the FCCH according to one embodiment of the disclosure.

[0011] FIG. **4** represents a flow of how an initial frequency estimation is calculated by the baseband processor according to one embodiment of the disclosure.

[0012] FIG. **5** illustrates a sliding window employed by the baseband processor to calculate an initial frequency estimation according to one embodiment of the disclosure.

[0013] FIG. **6** represents a flowchart that illustrates one way in which the baseband processor can refine the initial estimation according to one embodiment of the disclosure.

DETAILED DESCRIPTION

[0014] Embodiments of the present disclosure are directed to algorithms that facilitate acquisition of control channels in the GSM standard, such as, but not limited to, a Frequency Correction Channel (FCCH). During wireless data communication, the base stations transmit data bursts to the mobile devices or wireless terminals in TDMA frames. Each TDMA frame has eight time slots corresponding to eight data bursts, equivalently to data bursts for each multiframe. The data bursts belong to frequency correction channels FCCH, synchronization channels SCH, broadcast control channels BCCH, or common control channels CCCH.

[0015] The frequency correction channel FCCH data bursts do not contain training sequences, and comprises data burst of "zeros" or "ones" so that the mobile station can correct the local oscillator frequency error. The synchronization channel SCH is a downlink channel comprising regular sequences of bits that enables the mobile stations to synchronize received frame boundaries with the base stations on registration. The common control channel CCCH transfers data bursts containing training sequences known to the mobile stations for timing synchronization, supporting common procedures to establish a dedicated link between the base station and the mobile station. In the GSM specification, eight training sequences for normal bursts are specified, each base station utilizes a fixed training sequence thereof on all channels. The training sequence in the CCCH data burst is shorter than that of the synchronization burst in SCH, thus the timing synchronization provided by the CCCH data is less accurate than that of the SCH data. In the GSM systems, the common control channel CCCH includes RACH (Random Access Channel) for initial access to the GSM network, PCH (Paging Channel) indicating incoming calls or messages on waiting for the mobile station, and AGCH (Access Grant Channel) assigning the GSM network resource to another mobile station requesting the network access. The broadcast control channel BCCH is a downlink channel containing specific parameters required by the mobile station to identify the base station and obtain network access through the base station.

[0016] Accordingly, embodiments of the disclosure are related to acquisition algorithms for control channel data that reduce computational complexity relative to other implementations. To begin, a general architecture of an example GSM environment is shown and discussed. FIG. **1** is a system diagram illustrating a portion of a cellular wireless communication system **100** that supports wireless terminals operating according to the present invention. The cellular wireless communication system **100** includes a Mobile Switching Center (MSC) **101**, Serving GPRS Support Node/Serving EDGE Support Node (SGSN/SESN) **102**, base station controllers (BSCs) **152** and **154**, and base stations **103**, **104**, **105**, and **106**. The SGSN/SESN **102** couples to the Internet **114** via a GPRS Gateway Support Node (GGSN) **112**. A conventional voice terminal **121** couples to the PSTN **110**. A Voice over Internet Protocol (VoIP) terminal **123** and a personal computer **125** couple to the Internet **114**. The MSC **101** couples to the Public Switched Telephone Network (PSTN) **110**.

[0017] Each of the base stations **103-106** services a cell/set of sectors within which it supports wireless communications. Wireless links that include both forward link components and reverse link components support wireless communications between the base stations and their serviced wireless terminals. These wireless links support digital data communications, VoIP communications, and other digital multimedia communications. The cellular wireless communication system **100** may also be backward compatible in supporting analog operations as well. The cellular wireless communication system **100** supports the Global System for Mobile telecommunications (GSM) standard and also the Enhanced Data rates for GSM (or Global) Evolution (EDGE) extension thereof. The cellular wireless communication system **100** may also support the GSM General Packet Radio Service (GPRS) extension to GSM. However, the present invention is also applicable to other standards as well, e.g., TDMA standards, CDMA standards, etc. In general, the teachings of the present invention apply to digital communications that combine Automatic Repeat ReQuest (ARQ) operations at Layer 2, e.g., LINK/MAC layer with variable coding/decoding operations at Layer 1 (PHY).

[0018] Wireless terminals **116**, **118**, **120**, **122**, **124**, **126**, **128**, and **130** couple to the cellular wireless communication system **100** via wireless links with the base stations **103-106**. As illustrated, wireless terminals may include cellular telephones **116** and **118**, laptop computers **120** and **122**, desktop computers **124** and **126**, and data terminals **128** and **130**. However, the cellular wireless communication system **100** supports communications with other types of wireless terminals as well. As is generally known, devices such as laptop computers **120** and **122**, desktop computers **124** and **126**, data terminals **128** and **130**, and cellular telephones **116** and **118**, are enabled to "surf" the Internet **114**, transmit and receive data communications such as email, transmit and receive files, and to perform other data operations. Many of these data operations have significant download data-rate requirements while the upload data-rate requirements are not as severe. Some or all of the wireless terminals **116-130** are therefore enabled to support the GPRS and/or EDGE operating standard as well as supporting the voice servicing portions the GSM standard.

[0019] FIG. **2** is a block diagram functionally illustrating a mobile device **200** constructed according to the present invention. The mobile device **200** of FIG. **2** includes an RF transceiver **202**, a baseband processor **206**, a central processing unit (CPU) **208**, and various other components contained within a housing. The baseband processor **206** can perform physical layer processing, include a speech COder/DECoder, and other baseband functions that interact with the RF transceiver **202**. In one embodiment, the baseband processor **206** can comprise a Digital Signal Processor (DSP). The CPU **208** can interact with data provided by the baseband processor **206**, which represents decoded information received via the RF transceiver **202** as well as interact with the various other systems and components in the mobile device **200**, such as a display **220**, microphone **226**, speaker **228**, user input device **212**, camera **214**, LED's **222** and other components as can be appreciated that might be incorporated into a mobile device. The user input device **212** can include a capacitive touchscreen that is integrated within the display **220**, a keypad, other buttons or switches integrated into the mobile device **200**, or any other user input device as can be appreciated.

[0020] The mobile device **200** can also include a battery **224** or other power source that can provide power to the various components in the terminal. The terminal can also include one or more Subscriber Identification Module (SIM) port **213**, a flash RAM **216**, an SRAM **218**, or other system resources. The mobile device **200** can also include one or more ports **210**, which can comprise a universal serial bus (USB) port and its variants (e.g., micro-USB, mini-USB, etc.), a proprietary port, or any other input/output ports that can provide for data operations as well as power supply that can facilitate charging of the battery **224**.

[0021] Accordingly, reference is now made to FIG. **3**, which illustrates one embodiment of a state machine corresponding to the FCCH acquisition algorithm disclosed herein that is executed by the baseband processor **206** in response to an RF signal received by the RF transceiver **202**. The various stages of the state machine are discussed in further detail in the text as well as drawings that follow. In box **301**, the baseband processor **301** performs an initial frequency estimation of a carrier frequency, or presence of an FCCH signal. Generally, speaking, the process of box **301** is performed with a low probability of miss detection and a high probability of false alarm. Accordingly, in box **303**, the baseband processor **206** refines the initial frequency estimation to arrive at a more precise frequency estimation at which the FCCH tones are broadcast. In box **305**, the baseband processor **206** performs a final test that verifies the refinement of the initial estimation performed in box **303**. The FCCH acquisition method illustrated in FIG. **3** is generally executed by the baseband processor **206** every 156 GMSK symbols that are received, where the symbol rate, or F_{SYM}, as referred to herein, is approximately 270.8333 kHz.

[0022] Reference is now made to FIG. **4**, which illustrates one representation of the logic executed by the baseband processor **206** to perform an initial estimation of a carrier frequency corresponding to the FCCH as referenced in box **301** of the state machine shown in FIG. **3**. As noted above, the FCCH acquisition algorithm is executed every 156 GMSK symbols that are received by the baseband processor **206**. Accordingly, the baseband processor **206** receives 156 complex samples and divides the samples into four portions comprising thirty-nine samples. On each vector of thirty-nine samples, a subset of the samples is chosen (e.g., thirty-two samples) and a fast Fourier transform is executed as shown in box **401** to produce thirty-two frequency bins as shown below:

$$X_F(k)=\mathrm{FFT}(X_T(k))$$

Where:

$$X_T(k)=\{x_T(k,0),x_T(k,1),\ldots,x_T(k,N-1)\}$$

$$X_F(k)=\{x_F(k,0),x_F(k,1),\ldots,x_F(k,N-1)\}$$

[0023] In the above formulation, N can equal 32, or the number of samples of the GMSK symbols for which a fast Fourier transform is executed. A subset of the frequency bins can then be selected in box **403**. In one embodiment, the fourth through the twelfth bins can be selected as shown below:

$$\hat{x}_F(k,n)=x_F(k,n+4)$$

Where:

$$n=0,1,\ldots,8$$

[0024] This subset of the frequency bins can be selected because it can be assumed that the FCCH signal frequency is

$$\frac{F_{SYM}}{4}$$

as well as that the maximum frequency error is

$$\pm\frac{4\cdot F_{SYM}}{32}.$$

Accordingly, the energy of each selected bin can also be calculated as a square of its absolute value as shown below:

$$\hat{E}_F(k,n)=|\hat{x}_F(k,n)|^2$$

$$n=0,1,\ldots,8$$

[0025] In box **405**, each of the three last output vectors can be summed as shown below:

$$\hat{E}_{OUT}(k,n)=\hat{E}_F(k,n)+\hat{E}_F(k-1,n)+\hat{E}_F(k-2,n)$$

$$n=0,1,\ldots,8$$

[0026] In box **407**, a sliding window comprising sets of pairs of frequency bins can be generated as shown below:

$$E_{OUT}(k,n)=\hat{E}_{OUT}(k,n)+\hat{E}_{OUT}(k,n+1)\ n=0,1,\ldots,7$$

[0027] Such a sliding window **501** is further illustrated in FIG. **5** and is generated in the event that the carrier frequency may exist between neighbor bins, in which case the carrier frequency potentially manifests its presence both bins. Accordingly, a frequency bin associated with a maximum energy level is selected as is illustrated in the following pseudo code and represented in box:

$$Pntr(k)=\underset{n}{\mathrm{argmax}}(E_{OUT}(k,n))$$

[0028] where, Pntr(k) represents a pointer to a frequency bin and n=0,1, . . . , 7, and

$$E_{MAX}(k)=E_{OUT}(k,Pntr(k))$$

[0029] If (E_{MAX}(k)>Threshold) and (E_{MAX}(k)>E_{MAX}(k+1)) as shown in boxes **415** and **417**, the frequency bin corresponding to k is selected as the initial frequency estimation and a pointer to that bin is returned as shown in the following pseudocode:

if($\hat{E}_{OUT}(k,Pntr(k))>\hat{E}_{OUT}(k,Pntr(k)+1)$) return $Pntr(k)$

else return Pntr(k)+1

[0030] The threshold to which the energy level associated with a respective bin is compared can represent a minimum energy level associated with an FCCH signal.

[0031] Reference is now made to FIG. **6**, which illustrates one representation of the logic executed by the baseband processor **206** to perform an initial estimation of a carrier frequency corresponding to the FCCH as referenced in box **303** of the state machine shown in FIG. **3**. In other words, FIG. **6** illustrates a flowchart that shows one way in which the initial frequency estimation can be refined by the baseband processor **206** according to an embodiment of the disclosure.

[0032] In box **601**, the initial frequency estimation can be derotated as shown below:

$$\hat{X}(n)=X(n)\cdot\exp\left(-\frac{2\cdot p\cdot j\cdot n\cdot Pntr}{32}\right)$$

$$n=0,1,2,\ldots,5\cdot 39-1$$

[0033] Where Pntr is a pointer to a frequency bin associated with the initial frequency estimation. Next, in box **603**, the derotated initial frequency estimation can be downsampled to reduce computational complexity of the FCCH acquisition algorithm. In one embodiment, the signal sampling rate can be reduced by a factor of four and potentially even more without performance degradation. In one example, the derotated initial frequency estimation can be downsampled by a factor of four using an accumulator as a decimater as shown below:

$$Y(k) = \sum_{n=o}^{3} \hat{X}(4 \cdot k + n)$$

$$k = 0, 1, 2, \ldots , \frac{5 \cdot 39}{4} - 1$$

[0034] In box **603**, the downsampled and derotated initial frequency estimation can be autocorrelated for the purpose of improving the timing of the initial frequency estimation. In one embodiment, the correlator can be implemented as a sliding window in which thirty samples in the middle of the FCCH burst can be employed.

[0035] Next, in box **605**, the baseband processor **206** can execute a frequency estimation function on the result of the autocorrelation. The frequency estimation can be performed as shown below:

$$F_{EST} = \frac{F_{SYM}}{2 \cdot \pi \cdot M} \cdot \arctan\left[\frac{1}{N} \cdot \sum_{n=0}^{N-1} Y(n) \cdot Y^*(n + M)\right]$$

[0036] Where F_{EST} is the first frequency estimation, F_{SYM}=270.8333 KHz, Y is a first vector representing the autocorrected downsampled initial detection, and M and N are frequency estimation parameters. To generate the first frequency estimation, the frequency estimation parameter M can be set to 4 and N can be set to 26. However, it should be appreciated that other frequency estimation parameters can also be employed. In box **605**, the baseband processor **206** can derotate the first frequency estimation and in box **607**, the derotated frequency estimation can be used to generate a second frequency estimation by using frequency estimation parameters of M=20 and N=30. The second frequency estimation can be derotated to generate a refined frequency estimation.

[0037] Accordingly, as shown in box **305** of FIG. **3**, the baseband processor **205** can perform a final test of the refined frequency estimation to verify its accuracy as well as its timing. Accordingly, the baseband processor **206** can execute a mathematical filter that passes a signal through a filter and compares an energy of the filtered signal with a total received energy. A mathematical expression of such a final test is shown below:

$$\frac{\left|\frac{1}{N}\sum_{n=0}^{N-1} X(n) \cdot \exp(-2j \cdot \pi \cdot FrEstim \cdot n)\right|^2}{\frac{1}{N}\sum_{n=0}^{N-1} |X(n)|^2} > Thr$$

[0038] Where X(n) is the downsampled initial detection, N is a number of samples in the downsampled initial detection, FrEstim is the refined initial estimation, and Thr is a threshold to which the value resulting from execution of the filter is compared. If the refined initial estimation when passed through the filter exceeds the threshold, then the baseband processor **206** can declare that a carrier frequency has been acquired from the FCCH.

[0039] Any logic or functionality illustrated herein, if embodied in software, each block may represent a module, segment, or portion of code that comprises program instructions to implement the specified logical function(s). The program instructions may be embodied in the form of source code that comprises human-readable statements written in a programming language or machine code that comprises numerical instructions recognizable by a suitable execution system such as a processor in a computer system or other system. The machine code may be converted from the source code, etc. If embodied in hardware, each block may represent a circuit or a number of interconnected circuits to implement the specified logical function(s).

[0040] Although the flowcharts show a specific order of execution, it is understood that the order of execution may differ from that which is depicted. For example, the order of execution of two or more blocks may be scrambled relative to the order shown. Also, two or more blocks shown in succession may be executed concurrently or with partial concurrence. Further, in some embodiments, one or more of the blocks shown may be skipped or omitted. In addition, any number of counters, state variables, warning semaphores, or messages might be added to the logical flow described herein, for purposes of enhanced utility, accounting, performance measurement, or providing troubleshooting aids, etc. It is understood that all such variations are within the scope of the present disclosure.

[0041] Also, any logic or application described herein that comprises software or code can be embodied in any non-transitory computer-readable medium for use by or in connection with an instruction execution system such as, for example, a processor **803** in a computer system or other system. In this sense, the logic may comprise, for example, statements including instructions and declarations that can be fetched from the computer-readable medium and executed by the instruction execution system. In the context of the present disclosure, a "computer-readable medium" can be any medium that can contain, store, or maintain the logic or application described herein for use by or in connection with the instruction execution system. The computer-readable medium can comprise any one of many physical media such as, for example, magnetic, optical, or semiconductor media. More specific examples of a suitable computer-readable medium would include, but are not limited to, magnetic tapes, magnetic floppy diskettes, magnetic hard drives, memory cards, solid-state drives, USB flash drives, or optical discs. Also, the computer-readable medium may be a random access memory (RAM) including, for example, static random access memory (SRAM) and dynamic random access memory (DRAM), or magnetic random access memory (MRAM). In addition, the computer-readable medium may be a read-only memory (ROM), a programmable read-only memory (PROM), an erasable programmable read-only memory (EPROM), an electrically erasable programmable read-only memory (EEPROM), or other type of memory device.

[0042] It should be emphasized that the above-described embodiments of the present invention are merely possible examples of implementations, merely set forth for a clear understanding of the principles of the invention. Many variations and modifications may be made to the above-described embodiment(s) of the invention without departing substantially from the spirit and principles of the invention. All such modifications and variations are intended to be included herein within the scope of this disclosure and the present invention and protected by the following claims.

Therefore, having thus described the invention, at least the following is claimed:

1. A mobile device comprising:

a radio frequency (RF) transceiver;

a baseband processor in communication with the RF transceiver, the baseband processor executing a frequency correction channel (FCCH) acquisition module, the FCCH acquisition module comprising:

logic that performs an initial detection of a carrier frequency based on a plurality of GMSK symbols in the FCCH;

logic that refines the initial detection of the carrier frequency, wherein the refined initial detection downsamples the GMSK symbols by at least a factor of four; and

logic that verifies the refined initial detection of the carrier frequency by passing a signal through a mathematical filter and comparing an energy of the filtered signal to a threshold.

2. The mobile device of claim **1**, wherein a set of samples is selected from the GMSK symbols.

3. The mobile device of claim **2**, wherein the logic that performs an initial detection of the FCCH transmission frequency further comprises:

logic that performs a fast Fourier transform on the set of samples;

logic that calculates a total signal energy associated with a plurality of frequency bins resulting from the fast Fourier transform, wherein each of the frequency bins is associated with a frequency;

logic that selects a subset of the frequency bins; and

logic that calculates an energy of each of the selected subset of frequency bins and selects one of the selected subset of frequency bins associated with an energy value above a threshold as an initial frequency estimate.

4. The mobile device of claim **3**, wherein the logic that selects one of the frequency bins further comprises logic that determines whether a pair of consecutive frequency bins is associated with an energy value above the threshold and designating a frequency range associated with the pair of consecutive frequency bins.

5. The mobile device of claim **3**, wherein the plurality of frequency bins comprises thirty-two frequency bins, and the logic selects a subset of the frequency bins further comprises logic that selects a fourth through the twelfth frequency bins.

6. The mobile device of claim **1**, wherein the logic that refines the initial detection of the carrier frequency further comprises:

logic that derotates the initial detection; and

logic that downsamples the initial detection by summing a plurality of four consecutive GMSK symbols to produce a set of samples of the GMSK symbols.

7. The mobile device of claim **6**, wherein the logic that downsamples the initial detection downsamples the initial detection by a factor of four.

8. The mobile device of claim **6**, further comprising logic that performs an autocorrelation of the downsampled initial detection.

9. The mobile device of claim **8**, further comprising logic that generates a first frequency estimation of the autocorrelated downsampled initial detection by executing a frequency estimation function:

$$F_{EST} = \frac{F_{SYM}}{2\cdot\pi\cdot M}\cdot\arctan\left[\frac{1}{N}\cdot\sum_{n=0}^{N-1} Y(n)\cdot Y^*(n+M)\right]$$

where F_{EST} is the first frequency estimation, F_{SYM}=270.8333 KHz, Y is a first vector representing the autocorrected downsampled initial detection, and M and N are frequency estimation parameters.

10. The mobile device of claim **9**, wherein M=4 and N=26.

11. The mobile device of claim **10**, further comprising:

logic that performs a derotation of the first frequency estimates;

logic executes the frequency estimation function to generate a second frequency estimate, wherein M=10 and N=20; and

logic that performs a derotation of the second frequency estimate to generate the refined initial estimate.

12. The mobile device of claim **11**, wherein the mathematical filter comprises a mathematical filter function:

$$\frac{\left|\frac{1}{N}\sum_{n=0}^{N-1} X(n)\cdot\exp(-2j\cdot\pi\cdot FrEstim\cdot n)\right|^2}{\frac{1}{N}\sum_{n=0}^{N-1}|X(n)|^2} > Thr$$

where X(n) is the downsampled initial detection, N is a number of samples in the downsampled initial detection, FrEstim is the refined initial estimate, and Thr is the threshold.

13. A method executed in a mobile device for acquiring a carrier frequency from a frequency correction channel (FCCH), comprising:

performing an initial detection of the carrier frequency based on a plurality GMSK symbols in the FCCH;

refining the initial detection of the carrier frequency, wherein the refined initial detection downsamples the GMSK symbols by at least a factor of four; and

verifying the refined initial detection of the carrier frequency by passing a signal through a mathematical filter and comparing an energy of the filtered signal to a threshold. Attorney Docket: **50228-7220**

14. The method of claim **13**, wherein a set of samples is selected from the GMSK symbols and the step of performing an initial detection of the carrier frequency further comprises:

performing a fast Fourier transform on the set of samples;

calculating a total signal energy associated with a plurality of frequency bins resulting from the fast Fourier transform, wherein each of the frequency bins is associated with a frequency;

selecting a subset of the frequency bins; and

calculating an energy of each of the selected subset of frequency bins and selects one of the selected subset of frequency bins associated with an energy value above a threshold as an initial frequency estimate.

15. The method of claim **14**, wherein the step of selecting one of the frequency bins further comprises the step of determining whether a pair of consecutive frequency bins is associated with an energy value above the threshold and designating a frequency range associated with the pair of consecutive frequency bins.

16. The method of claim **14**, wherein the plurality of frequency bins comprises thirty-two frequency bins, and the step of selecting a subset of the frequency bins further comprises logic that selects a fourth through the twelfth frequency bins.

17. The method of claim **13**, wherein the step of refining the initial detection of the carrier frequency further comprises:

derotating the initial detection; and

downsampling the initial detection by a factor of four.

18. The method of claim **17**, further comprising:

performing an autocorrelation of the downsampled initial detection;

generating a first frequency estimation of the autocorrelated downsampled initial detection by executing a frequency estimation function;

performing a derotation of the first frequency estimation;

generating a second frequency estimation by executing the frequency estimation function; and

performing a derotation of the second frequency estimation to generate the refined initial estimate.

19. The method of claim **13**, wherein the mathematical filter comprises a mathematical filter function:

$$\frac{\left|\frac{1}{N}\sum_{n=0}^{N-1} X(n)\cdot\exp(-2j\cdot\pi\cdot FrEstim\cdot n)\right|^2}{\frac{1}{N}\sum_{n=0}^{N-1}|X(n)|^2} > Thr$$

where X(n) is the downsampled initial detection, N is a number of samples in the downsampled initial detection, FrEstim is the refined initial estimate, and Thr is the threshold.

20. A system, comprising:

means performing an initial detection of the carrier frequency based on a plurality GMSK symbols in a frequency correction channel (FCCH);

means for refining the initial detection of the carrier frequency, wherein the refined initial detection downsamples the GMSK symbols by at least a factor of four; and

means for verifying the refined initial detection of the carrier frequency by passing a signal through a mathematical filter and comparing an energy of the filtered signal to a threshold.

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