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(54) **SYSTEMS AND METHODS FOR LOCATING ALL SYNCHRONIZATION SIGNAL BLOCKS ON A 5G NR CHANNEL**

SYSTEME UND VERFAHREN ZUR LOKALISIERUNG ALLER SYNCHRONISATIONSSIGNALBLÖCKE AUF EINEM 5G-NR-KANAL

SYSTÈMES ET PROCÉDÉS DE LOCALISATION DE TOUS LES BLOCS DE SIGNAUX DE SYNCHRONISATION SUR UN CANAL NR 5G

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Description

FIELD

[0001] The present invention relates generally to radio frequency (RF) communications hardware. More particularly, the present invention relates to systems and methods for locating all synchronization signal blocks (SSBs) on a 5G new radio (NR) channel.

BACKGROUND

[0002] Wireless cellular technology has expanded to adopt a 5G standard that can operate in a stand-alone mode or a non-stand-alone mode and include use of a 5G NR channel that can have one or more SSBs. In the stand-alone mode, the 5G NR channel can include only one cell-defining SSB located on a wide global synchronization raster with a corresponding global synchronization channel number (GSCN). For example, for a frequency range above 24.25 GHz (i.e., an FR2 section of the 5G standard), a GSCN raster step size is 17.28 MHz. Because there are only several candidate frequencies to search for, user equipment can feasibly search for the cell-defining SSB at start up, and after the user equipment is connected to the 5G NR channel, the user equipment can receive radio resource control commands to search for other SSBs at different frequencies that are not necessarily on the global synchronization raster. The other SSBs can be located on any frequency within a bandwidth of the 5G NR channel bandwidth on a new radio absolute radio frequency channel number (NR-ARFCN) raster, which is narrower than the global synchronization raster. For example, for the FR2 section of the 5G standard, a NR-ARFCN raster step size is only 60 KHz. Accordingly, locating the other SSBs in the stand-alone mode is feasible. In the non-stand-alone mode, the user equipment can receive SSB frequency information from a radio resource control command after the user equipment is connected to a 4G LTE network, but in the non-stand-alone mode the SSBs do not have to be located on the global synchronization raster. Accordingly, locating the SSBs in the non-stand-alone mode is also feasible.

[0003] In some instances, network monitoring and measuring can require blindly searching for and identifying all of the SSBs of the 5G NR channel, not just the one cell-defining SSB, thereby requiring the user equipment to search every NR-ARFCN raster frequency for a valid cell. However, the bandwidth of the 5G NR channel is wide. For example, a minimum channel bandwidth is 100 MHz for the FR2 frequency section of the 5G standard, a maximum channel bandwidth is 400MHz for the FR2 frequency section of the 5G standard, and the bandwidth of the SSB is typically 28.8 MHz for a sub-carrier spacing (SCS) of 120 KHz. These features of the 5G NR channel mean that, for the FR2 frequency section of the 5G standard, one of the SSBs can be located on, at a minimum, any one of 1186 NR-ARFCN raster frequencies. Thus, in order to blindly scan for and identify all of the SSBs, a scanning receiver needs to perform a primary synchronization signal (PSS) correlation search on every sample time offset for each raster frequency candidate, which can be prohibitive in terms of time and cost when multiplied with a large number of frequencies. The document "Remaining details on SS block transmissions", 3GPP DRAFT; R1-1720853, 2017-11-01 discloses that in wideband CC, multiple SS blocks are transmitted with frequency locations irrespective of frequency locations of other SS blocks. This gives maximum flexibility, but to know frequency locations of the SS blocks, the UE needs to blindly search all possible frequency locations of SS block, i.e., on synchronization signal raster. Increases SS block searching effort and power consumption.

[0004] The document WO2019070184, ERICSSON TELEFON AB, 2019-04-11 discloses that the first step during initial access is to determine the presence of a carrier frequency over which the cell operates. To do this the UE typically estimates energy over a certain frequency range in a certain time period and compares with energy threshold to determine whether one or more cells may operate on carrier frequency or in a certain carrier frequency range.

[0005] In view of the above, there is a continuing, ongoing need for improved systems and methods.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

FIG. 1 is a graph of OFDM symbol alignment at different frequencies as known in the art;
FIG. 2 is a graph of CP-OFDM use on a 5G NR channel in a downlink transmission as known in the art;
FIG. 3 is a block diagram of a system according to disclosed embodiments;
FIG. 4 is a flow diagram of a method according to disclosed embodiments; and
FIG. 5 is a flow diagram of a method according to disclosed embodiments.

[0007] The invention is as defined in the independent claims.

DETAILED DESCRIPTION

[0008] Embodiments disclosed herein can include systems and methods for locating all SSBs on a 5G NR channel. In particular, as seen in FIG. 1, it is known that the 5G NR channel uses orthogonal frequency-division multiplexing (OFDM) symbols that are synchronized in time for different frequencies and different SCS sizes. The system and methods described herein can identify global OFDM symbol boundaries for all of the 5GNR channel and then apply the global OFDM symbol boundaries to all raster frequencies of the 5G NR channel to identify all of the SSBs.

[0009] The systems and methods described herein include measuring downlink signal energy over a bandwidth of the 5G NR channel to identify a center frequency of a signal broadcast on the 5G NR channel. Then, the systems and methods described herein include processing the signal at the center frequency of the signal to identify a first one of the SSBs and the global OFDM symbol boundaries for the 5G NR channel and using the global OFDM symbol boundaries for all of the raster frequencies of the 5G NR channel to identify remaining ones of the SSBs.

[0010] In some embodiments, measuring the downlink signal energy can also include identifying frequency edges of the signal, and in these embodiments, the systems and methods described herein can identify the center frequency of the signal and the frequency edges of the signal by using a slope algorithm to identify a power and a bandwidth of the signal.

[0011] In some embodiments, the 5G NR channel can be located adjacent to LTE channels, and in these embodiments, measuring the downlink signal energy can include locking to the LTE channels instead of the 5G NR channel. However, because the LTE channels are synchronized in time with the 5G NR channel, the global OFDM symbol boundaries of the LTE channels and the 5G NR channel are aligned. Therefore, when the systems and methods described herein lock to the LTE channels, the systems and methods described herein also lock to the 5G NR channels.

[0012] In some embodiments, the systems and methods described herein can include calculating a cyclic prefix (CP) correlation of the signal at the center frequency of the signal to identify the first one of the SSBs and the global OFDM symbol boundaries. In particular, as seen in FIG. 2, it is known that the 5G NR channel uses CP-OFDM in a downlink transmission, which copies a CP length T_{cp} of a last portion of a current OFDM symbol of length $T\mu$ and inserts that CP length T_{cp} ahead of the current OFDM symbol. The systems and methods described herein can use this repetition of the CP length to perform the CP correlation. For example, where a sampled signal sequence is s(i), i = 0, 1 ... M, an OFDM symbol length is N samples, and the CP length is CP, the CP correlation can be calculated for an offset i using Equation 1.

Equation 1: $$Corr_{CP}(i) = \sum_{k=0}^{CP-1} s(i) * s(i+N)^*$$

[0013] In some embodiments, the CP correlation of the signal can be calculated at the center frequency of the signal as a moving correlation. For example, when calculating the CP correlation for a next sample time offset, an oldest term can be removed from the summation, and a new term can be added. In some embodiments, results of the CP correlation can be complex numbers that can be squared to identify an energy value for comparison. In these embodiments, OFDM symbol start timing can be found by a maximum squared CP correlation peak, and this OFDM symbol boundary can be applied to all of the raster frequencies of the 5G NR channel thereafter.

[0014] In some embodiments, the downlink transmission can include both a data transmission and a sync transmission (e.g., the SSBs), and in these embodiments, the SSBs can use a different SCS than the data transmission. For example, in the FR2 frequency section of the 5G standard, the data transmission can use a SCS of 60 KHz, but the SSBs can use a SCS of 120 KHz. This larger SCS can provide more resistance to frequency drift introduced by an oscillator at a mmWave frequency. In particular, as seen in FIG. 1, the CP length of a first OFDM symbol of a 0.5 ms long half sub-frame can be longer than the CP length of other OFDM symbols. This differentiation in length is designed to align half sub-frames for different sizes of SCS. For example, Table 1 identifies the CP length of all of the OFDM symbols when an OFDM sample length is 512 samples.

Table 1, CP Length of Different Numerology for Normal CP

SCS (KHz)	CP length of 1st OFDM symbol	CP length of rest OFDM symbols
15	40	36
30	44	36
60	52	36
120	68	36

(continued)

SCS (KHz)	CP length of 1st OFDM symbol	CP length of rest OFDM symbols
240	100	36

[0015] The 5G NR channel is designed to have flexible slot formats configured to be downlink, uplink, or flexible, but the first OFDM symbol is always downlink or flexible, and the other OFDM symbols can be any of downlink, uplink, or flexible. Therefore, the first OFDM symbol has a greater chance than the other OFDM symbols to receive the downlink transmission, which, together with the CP length that is longer, makes it more desirable to correlate with the CP length of the first OFDM symbol if present. However, it is possible that the CP length of the first OFDM symbol is not present, and under such circumstances, the CP correlation of the signal at the center frequency of the signal can be calculated twice: one time assuming a first SCS (e.g. 60 KHz) and another time assuming a second, different SCS (e.g. 120 KHz). Then, the systems and methods described herein can select a result from both of such calculations with a highest correlation value to use in identifying the first one of the SSBs and the global OFDM symbol boundaries.

[0016] In some embodiments, after the global OFDM symbol boundaries are identified, the systems and methods described herein can include calculating a PSS correlation at the global OFDM symbol boundaries for all of the raster frequencies to identify the remaining ones of the SSBs. Advantageously, the systems and methods described herein have substantially reduced processing time when compared with known systems and methods because the PSS correlation on all of the raster frequencies does not need to be performed at every sample time offset. Instead, the PSS correlation can be limited to only the global OFDM symbol boundaries.

[0017] For example, in known systems and methods where the PSS correlation is performed at every sample time offset for every NR-ARFCN raster frequency, the OFDM symbol length is 512 samples, and the CP length is 36 samples, the PSS correlation needs to be repeated for all 548 possible sample time offsets. With a large number of NR-ARFCN raster frequencies, total processing is very high, which results in a low scan speed. However, in the systems and methods described herein where the PSS correlation is only calculated at the global OFDM symbol boundaries identified, signal processing can theoretically be performed only once versus the 548 times required by known systems and methods for a total processing saving time of 548:1.

[0018] In embodiments in which the CP length of the first OFDM symbol of every half sub-frame is longer than the CP length of the other OFDM symbols, the CP correlation can only identify the global OFDM symbol boundaries, but not an OFDM symbol index within the half sub-frame. Therefore, in these embodiments, when the global OFDM symbol boundaries are applied to all of the raster frequencies, the PSS correlation can be calculated twice: one time where the global OFDM symbol boundaries for all of the raster frequencies are presumed to identify the first OFDM symbol in the half sub-frame and another time where the global OFDM symbol boundaries for all of the raster frequencies are not presumed to identify the first OFDM symbols in the half sub-frame. Thus, where the PSS correlation is performed twice, the amount of processing saving time as compared with known systems and methods can be reduced to 548:2.

[0019] In some embodiments, the systems and methods described herein can perform a secondary synchronization signal correlation at peak values for results of the PSS correlation for all of the raster frequencies to identify the remaining ones of the SSBs. For example, in some embodiments, the systems and methods described herein can perform DM-RS correlation at the global OFDM symbol boundaries for all of the raster frequencies to identify channel estimates, and the systems and methods described herein can perform MIB decoding and demodulation on the channel estimates to identify the remaining ones of the SSBs.

[0020] The systems and methods described herein can be used to find all valid LTE channels of a specific LTE band. For example, for LTE bands above 2 GHz with a total bandwidth in a range of 100 MHz and an LTE channel raster size of 100 KHz, a channel search in known systems and methods can start with the PSS correlation on every sample time offset. However, the systems and methods described herein can perform the CP correlation to identify the global OFDM symbol boundaries on every 5 MHz frequency step. Then, the systems and methods described herein can use the global OFDM symbol boundaries to perform the PSS correlation only at the global OFDM symbol boundaries for all candidate raster frequencies within 5 MHz.

[0021] FIG. 3 is a block diagram of an RF communications system 20 according to disclosed embodiments. As seen in FIG. 3, the RF communications system 20 can include user equipment 22 and broadcast equipment 23, and the user equipment 22 can include a programmable processor 26 and an RF transceiver 24 that can receive RF signals broadcast by the broadcast equipment 23.

[0022] FIG. 4 is a flow diagram of a method 100 according to disclosed embodiments. As seen in FIG. 4, the method 100 can include the programmable processor 26 measuring downlink signal energy over a bandwidth of a wireless radio channel to identify a center frequency of a signal broadcast on the wireless radio channel by the broadcast equipment 23, as in 102. Then, the method 100 can include the programmable processor 26 processing the signal at the center frequency of the signal to identify a first of a plurality of SSBs and global OFDM symbol boundaries for the wireless radio channel, as in 104. Finally, the method 100 can include the programmable processor 26 using the global OFDM symbol boundaries for all raster frequencies of the wireless radio channel to identify remaining ones of the plurality of SSBs, as in 106.

[0023] FIG. 5 is a flow diagram of a method 200 according to disclosed embodiments and illustrates one embodiment of the method 100 of FIG. 4. As seen in FIG. 5, the method 200 can include the programmable processor 26 measuring downlink signal energy over a bandwidth of a wireless radio channel to identify a center frequency of a signal broadcast on the wireless radio channel by the broadcast equipment 23, as in 202. Then, the method 200 can include the programmable processor 26 calculating a CP correlation of the signal at the center frequency of the signal to identify a first SSB and global OFDM symbol boundaries for the wireless radio channel, as in 204. Next, the method 200 can include the programmable processor 26 identifying whether a next SSB is present on a next raster frequency of the wireless radio channel by calculating a PSS correlation at the global OFDM symbol boundaries for the next raster frequency, performing a secondary synchronization signal correlation at peak values for results of the PSS correlation, performing DM-RS correlation at the global OFDM symbol boundaries for the next raster frequency to identify channel estimates, and performing MIB decoding and demodulation on the channel estimates, as in 206.

[0024] After identifying whether the next SSB is present on the next raster frequency as in 206, the method 200 can include the programmable processor 26 determining whether each raster frequency been searched for the next SSB, as in 208. If so, then the method 200 can terminate, as in 210. However, when each raster frequency has not been searched, the method 200 can include the programmable processor 26 continuing to identify whether a next synchronization signal block is present on a next raster frequency of the wireless radio channel, as in 206.

Claims

1. A method comprising:

measuring downlink signal energy over a bandwidth of a wireless radio channel to identify a center frequency of a signal broadcast on the wireless radio channel;
processing the signal at the center frequency of the signal to identify a first of a plurality of synchronization signal blocks and global orthogonal frequency-division multiplexing - OFDM - symbol boundaries for the wireless radio channel; and
using the global OFDM symbol boundaries for all raster frequencies of the wireless radio channel to identify remaining ones of the plurality of synchronization signal blocks.

2. The method of claim 1 further comprising:

calculating a cyclic prefix correlation of the signal at the center frequency of the signal to identify the first of the plurality of synchronization signal blocks and the global OFDM symbol boundaries; and
calculating a primary synchronization signal correlation at the global OFDM symbol boundaries for all of the raster frequencies to identify the remaining ones of the plurality of synchronization signal blocks.

3. The method of claim 2 further comprising:
performing a secondary synchronization signal correlation at peak values for results of the primary synchronization signal correlation for all of the raster frequencies.

4. The method of claim 2 or 3 further comprising:

performing demodulation reference signal - DM-RS - correlation at the global OFDM symbol boundaries for all of the raster frequencies to identify channel estimates; and
performing master information block - MIB - decoding and demodulation on the channel estimates.

5. The method of claim 2, 3 or 4 further comprising:

calculating the primary synchronization signal correlation at the global OFDM symbol boundaries for all of the raster frequencies by calculating the primary synchronization signal correlation on each of the OFDM symbol boundaries for all of the raster frequencies a first time and calculating the primary synchronization signal correlation on each of the OFDM symbol boundaries for all of the raster frequencies a second time,
wherein, for the first time, the global OFDM symbol boundaries for all of the raster frequencies are presumed to indicate a first OFDM symbol in a half sub-frame of the signal, and

wherein, for the second time, the global OFDM symbol boundaries for all of the raster frequencies are not presumed to indicate the first OFDM symbol in the half sub-frame of the signal.

6. The method of claim 2, 3, 4 or 5 further comprising:

calculating the cyclic prefix correlation of the signal at the center frequency of the signal by calculating the cyclic prefix correlation of the signal at the center frequency of the signal a first time, calculating the cyclic prefix correlation of the signal at the center frequency of the signal a second time, and selecting a result of the cyclic prefix correlation with a highest correlation value to use in identifying the first of the plurality of synchronization signal blocks and the global OFDM symbol boundaries,
wherein, for the first time, a sub-carrier spacing of the signal is presumed to be a first value, and
wherein, for the second time, the sub-carrier spacing of the signal is presumed to be a second value that is different from the first value.

7. The method of any one of claims 2 to 6 further comprising:
calculating the cyclic prefix correlation of the signal at the center frequency of the signal as a moving correlation.

8. The method of any one of claims 2 to 7 further comprising:
identifying maximum squared peak output values from the cyclic prefix correlation to identify the global OFDM symbol boundaries.

9. The method of any preceding claim wherein the wireless radio channel includes a 5G radio channel.

10. The method of any preceding claim further comprising:
identifying frequency edges of the signal from measuring the downlink signal energy.

11. A system comprising:

a radio frequency transceiver; and
a programmable processor,
wherein the radio frequency transceiver receives a signal broadcast on a wireless radio channel, and
wherein the programmable processor measures downlink signal energy over a bandwidth of the wireless radio channel to identify a center frequency of the signal, processes the signal at the center frequency of the signal to identify a first of a plurality of synchronization signal blocks and global OFDM symbol boundaries for the wireless radio channel, and uses the global OFDM symbol boundaries for all raster frequencies of the wireless radio channel to identify remaining ones of the plurality of synchronization signal blocks.

12. The system of claim 11 wherein the programmable processor calculates a cyclic prefix correlation of the signal at the center frequency of the signal to identify the first of the plurality of synchronization signal blocks and the global OFDM symbol boundaries, wherein the programmable processor calculates a primary synchronization signal correlation at the global OFDM symbol boundaries for all of the raster frequencies to identify the remaining ones of the plurality of synchronization signal blocks, and wherein the programmable processor performs a secondary synchronization signal correlation at peak values for results of the primary synchronization signal correlation for all of the raster frequencies.

13. The system of claim 12 wherein the programmable processor performs demodulation reference signal - DM-RS - correlation at the global OFDM symbol boundaries for all of the raster frequencies to identify channel estimates, and wherein the programmable processor performs master information block - MIB - decoding and demodulation on the channel estimates.

14. The system of claim 12 or 13 wherein the programmable processor calculates the primary synchronization signal correlation at the global OFDM symbol boundaries for all of the raster frequencies by calculating the primary synchronization signal correlation on each of the OFDM symbol boundaries for all of the raster frequencies a first time and calculating the primary synchronization signal correlation on each of the OFDM symbol boundaries for all of the raster frequencies a second time, wherein, for the first time, the global OFDM symbol boundaries for all of the raster frequencies are presumed to indicate a first OFDM symbol in a half sub-frame of the signal, and wherein, for the second time, the global OFDM symbol boundaries for all of the raster frequencies are not presumed to indicate the first OFDM symbol in the half sub-frame of the signal.

15. The system of claim 12, 13 or 14 wherein the programmable processor calculates the cyclic prefix correlation of the signal at the center frequency of the signal by calculating the cyclic prefix correlation of the signal at the center frequency of the signal a first time, calculating the cyclic prefix correlation of the signal at the center frequency of the signal a second time, and selecting a result of the cyclic prefix correlation with a highest correlation value to use in identifying the first of the plurality of synchronization signal blocks and the global OFDM symbol boundaries, wherein, for the first time, a sub-carrier spacing of the signal is presumed to be a first value, wherein, for the second time, the sub-carrier spacing of the signal is presumed to be a second value that is different from the first value, wherein the programmable processor calculates the cyclic prefix correlation of the signal at the center frequency of the signal as a moving correlation, and wherein the programmable processor identifies maximum squared peak output values from the cyclic prefix correlation to identify the global OFDM symbol boundaries.

Patentansprüche

1. Verfahren, umfassend:

   Messen von Downlink-Signalenergie über eine Bandbreite eines drahtlosen Funkkanals, um eine Mittenfrequenz eines auf dem drahtlosen Funkkanal ausgestrahlten Signals zu identifizieren;
   Verarbeiten des Signals bei der Mittenfrequenz des Signals, um einen ersten einer Vielzahl von Synchronisationssignalblöcken und globale Symbolgrenzen von orthogonalem Frequenzmultiplexverfahren - OFDM - für den drahtlosen Funkkanal zu identifizieren; und
   Verwenden der globalen OFDM-Symbolgrenzen für alle Rasterfrequenzen des drahtlosen Funkkanals, um die verbleibenden Blöcke aus der Vielzahl von Synchronisationssignalblöcken zu identifizieren.

2. Verfahren gemäß Anspruch 1, ferner umfassend:

   Berechnen einer zyklischen Präfixkorrelation des Signals bei der Mittenfrequenz des Signals, um den ersten der Vielzahl von Synchronisationssignalblöcken und die globalen OFDM-Symbolgrenzen zu identifizieren; und
   Berechnen einer primären Synchronisationssignalkorrelation an den globalen OFDM-Symbolgrenzen für alle Rasterfrequenzen, um die verbleibenden Blöcke der Vielzahl von Synchronisationssignalblöcken zu identifizieren.

3. Verfahren gemäß Anspruch 2, ferner umfassend:
   Ausführen einer sekundären Synchronisationssignalkorrelation bei Peak-Werten für Resultate der primären Synchronisationssignalkorrelation für alle der Rasterfrequenzen.

4. Verfahren gemäß Anspruch 2 oder 3, ferner umfassend:

   Ausführen einer Korrelation von Demodulationsreferenzsignal - DM-RS - an den globalen OFDM-Symbolgrenzen für alle Rasterfrequenzen, um Kanalschätzungen zu identifizieren; und
   Ausführen einer Dekodierung und Demodulation von Master-Informationsblock (MIB) über die Kanalschätzungen.

5. Verfahren gemäß Anspruch 2, 3 oder 4, ferner umfassend:

   Berechnen der primären Synchronisationssignalkorrelation an den globalen OFDM-Symbolgrenzen für alle Rasterfrequenzen durch Berechnen der primären Synchronisationssignalkorrelation an jeder der OFDM-Symbolgrenzen für alle Rasterfrequenzen ein erstes Mal und Berechnen der primären Synchronisationssignalkorrelation an jeder der OFDM-Symbolgrenzen für alle Rasterfrequenzen ein zweites Mal,
   wobei beim ersten Mal davon ausgegangen wird, dass die globalen OFDM-Symbolgrenzen für alle Rasterfrequenzen ein erstes OFDM-Symbol in einem halben Subframe des Signals angeben, und
   wobei beim zweiten Mal nicht davon ausgegangen wird, dass die globalen OFDM-Symbolgrenzen für alle Rasterfrequenzen das erste OFDM-Symbol in dem halben Subframe des Signals angeben.

6. Verfahren gemäß Anspruch 2, 3, 4 oder 5, ferner umfassend:

   Berechnen der zyklischen Präfixkorrelation des Signals bei der Mittenfrequenz des Signals durch Berechnen der zyklischen Präfixkorrelation des Signals bei der Mittenfrequenz des Signals ein erstes Mal, Berechnen der

zyklischen Präfixkorrelation des Signals bei der Mittenfrequenz des Signals ein zweites Mal, und Auswählen eines Ergebnisses der zyklischen Präfixkorrelation mit einem höchsten Korrelationswert zur Verwendung beim Identifizieren des ersten aus der Vielzahl von Synchronisationssignalblöcken und der globalen OFDM-Symbolgrenzen,
wobei beim ersten Mal ein Unterträgerabstand des Signals als ein erster Wert angenommen wird, und
wobei für den zweiten Zeitpunkt angenommen wird, dass der Unterträgerabstand des Signals ein zweiter Wert ist, der sich von dem ersten Wert unterscheidet.

7. Verfahren gemäß einem der Ansprüche 2 bis 6, ferner umfassend:
Berechnen der zyklischen Präfixkorrelation des Signals bei der Mittenfrequenz des Signals als gleitende Korrelation.

8. Verfahren gemäß einem der Ansprüche 2 bis 7, ferner umfassend:
Identifizieren der maximalen quadrierten Peak-Ausgangswerte aus der zyklischen Präfixkorrelation, um die globalen OFDM-Symbolgrenzen zu identifizieren.

9. Verfahren gemäß einem der vorherigen Ansprüche, wobei der drahtlose Funkkanal einen 5G-Funkkanal beinhaltet.

10. Verfahren gemäß einem vorherigen Anspruch, ferner umfassend:
Identifizieren von Frequenzflanken des Signals durch Messen der Downlink-Signalenergie.

11. System, umfassend:

einen Hochfrequenz-Sendeempfänger und einen programmierbaren Prozessor,
wobei der Hochfrequenz-Sendeempfänger ein Signal empfängt, das auf einem drahtlosen Funkkanal gesendet wird, und
wobei der programmierbare Prozessor die Downlink-Signalenergie über eine Bandbreite des drahtlosen Funkkanals misst, um eine Mittenfrequenz des Signals zu identifizieren, das Signal bei der Mittenfrequenz des Signals verarbeitet, um einen ersten einer Vielzahl von Synchronisationssignalblöcken und globale OFDM-Symbolgrenzen für den drahtlosen Funkkanal zu identifizieren, und die globalen OFDM-Symbolgrenzen für alle Rasterfrequenzen des drahtlosen Funkkanals verwendet, um verbleibende der Vielzahl von Synchronisationssignalblöcken zu identifizieren.

12. System gemäß Anspruch 11, wobei der programmierbare Prozessor eine zyklische Präfixkorrelation des Signals bei der Mittenfrequenz des Signals berechnet, um den ersten der Vielzahl von Synchronisationssignalblöcken und die globalen OFDM-Symbolgrenzen zu identifizieren, wobei der programmierbare Prozessor eine primäre Synchronisationssignalkorrelation an den globalen OFDM-Symbolgrenzen für alle Rasterfrequenzen berechnet, um die verbleibenden der Vielzahl von Synchronisationssignalblöcken zu identifizieren, und wobei der programmierbare Prozessor eine sekundäre Synchronisationssignalkorrelation bei Peak-Werten für Resultate der primären Synchronisationssignalkorrelation für alle Rasterfrequenzen ausführt.

13. System gemäß Anspruch 12, wobei der programmierbare Prozessor eine Demodulationsreferenzsignal-Korrelation - DM-RS-Korrelation - an den globalen OFDM-Symbolgrenzen für alle Rasterfrequenzen ausführt, um Kanalschätzungen zu identifizieren, und wobei der programmierbare Prozessor eine Dekodierung und Demodulation von Master-Informationsblock (MIB) über die Kanalschätzungen ausführt.

14. System gemäß Anspruch 12 oder 13, wobei der programmierbare Prozessor die primäre Synchronisationssignalkorrelation an den globalen OFDM-Symbolgrenzen für alle Rasterfrequenzen berechnet, indem er die primäre Synchronisationssignalkorrelation an jeder der OFDM-Symbolgrenzen für alle Rasterfrequenzen ein erstes Mal berechnet und die primäre Synchronisationssignalkorrelation an jeder der OFDM-Symbolgrenzen für alle Rasterfrequenzen ein zweites Mal berechnet, wobei für das erste Mal angenommen wird, dass die globalen OFDM-Symbolgrenzen für alle Rasterfrequenzen ein erstes OFDM-Symbol in einem halben Subframe des Signals angeben, und wobei für das zweite Mal angenommen wird, dass die globalen OFDM-Symbolgrenzen für alle Rasterfrequenzen nicht das erste OFDM-Symbol in dem halben Subframe des Signals angeben.

15. System gemäß Anspruch 12, 13 oder 14, wobei der programmierbare Prozessor die zyklische Präfixkorrelation des Signals bei der Mittenfrequenz des Signals durch Berechnen der zyklischen Präfixkorrelation des Signals bei der Mittenfrequenz des Signals ein erstes Mal, Berechnen der zyklischen Präfixkorrelation des Signals bei der Mittenfrequenz des Signals ein zweites Mal, und Auswählen eines Ergebnisses der zyklischen Präfixkorrelation mit einem höchsten Korrelationswert zur Verwendung beim Identifizieren des ersten aus der Vielzahl von Synchronisationssignalblöcken und der globalen OFDM-Symbolgrenzen berechnet, wobei beim ersten Mal ein Unterträgerabstand des Signals als ein erster Wert angenommen wird, wobei für den zweiten Zeitpunkt angenommen wird, dass der Unterträgerabstand des Signals ein zweiter Wert ist, der sich von dem ersten Wert unterscheidet, wobei der programmierbare Prozessor die zyklische Präfixkorrelation des Signals bei der Mittenfrequenz des Signals als gleitende Korrelation berechnet, und wobei der programmierbare Prozessor die maximalen quadrierten Peak-Ausgangswerte aus der zyklischen Präfixkorrelation identifiziert, um die globalen OFDM-Symbolgrenzen zu identifizieren.

Revendications

1. Un procédé comprenant :

la mesure de l'énergie du signal de liaison descendante sur une largeur de bande d'un canal radio sans fil pour identifier une fréquence centrale d'un signal diffusé sur le canal radio sans fil ;
le traitement du signal à la fréquence centrale du signal pour identifier un premier d'une pluralité de blocs de signaux de synchronisation et des limites globales de symbole de multiplexage par répartition orthogonale de la fréquence - OFDM - pour le canal radio sans fil ; et
l'utilisation des limites globales de symbole OFDM pour toutes les fréquences de trame du canal radio sans fil pour identifier les blocs restants de la pluralité de blocs de signaux de synchronisation.

2. Le procédé selon la revendication 1 comprenant en outre :

le calcul d'une corrélation de préfixe cyclique du signal à la fréquence centrale du signal pour identifier le premier de la pluralité de blocs de signaux de synchronisation et les limites globales de symbole OFDM ; et
le calcul d'une corrélation de signal de synchronisation primaire aux limites globales de symbole OFDM pour toutes les fréquences de trame pour identifier les blocs restants de la pluralité de blocs de signaux de synchronisation.

3. Le procédé selon la revendication 2 comprenant en outre :
l'exécution d'une corrélation de signal de synchronisation secondaire à des valeurs de crête pour des résultats de la corrélation de signal de synchronisation primaire pour toutes les fréquences de trame.

4. Le procédé selon la revendication 2 ou 3 comprenant en outre :

l'exécution d'une corrélation de signal de référence de démodulation - DM-RS - aux limites globales de symbole OFDM pour toutes les fréquences de trame pour identifier des estimations de canal ; et
l'exécution d'un décodage et d'une démodulation du bloc d'informations maître - MIB - sur les estimations de canal.

5. Le procédé selon la revendication 2, 3 ou 4 comprenant en outre :

le calcul de la corrélation de signal de synchronisation primaire aux limites globales de symbole OFDM pour toutes les fréquences de trame en calculant la corrélation de signal de synchronisation primaire sur chacune des limites de symbole OFDM pour toutes les fréquences de trame une première fois et en calculant la corrélation de signal de synchronisation primaire sur chacune des limites de symbole OFDM pour toutes les fréquences de trame une deuxième fois,
dans lequel, pour la première fois, les limites globales de symbole OFDM pour toutes les fréquences de trame sont supposées indiquer un premier symbole OFDM dans une demi-sous-trame du signal, et
dans lequel, pour la deuxième fois, les limites globales de symbole OFDM pour toutes les fréquences de trame ne sont pas supposées indiquer le premier symbole OFDM dans la demi-sous-trame du signal.

6. Le procédé selon la revendication 2, 3, 4 ou 5 comprenant en outre :

le calcul de la corrélation de préfixe cyclique du signal à la fréquence centrale du signal en calculant la corrélation de préfixe cyclique du signal à la fréquence centrale du signal une première fois, en calculant la corrélation de préfixe cyclique du signal à la fréquence centrale du signal une deuxième fois, et en sélectionnant un résultat de la corrélation de préfixe cyclique avec une valeur de corrélation la plus élevée à utiliser pour identifier le

premier de la pluralité de blocs de signaux de synchronisation et les limites globales de symbole OFDM, dans lequel, pour la première fois, un espacement de sous-porteuse du signal est supposé être une première valeur, et
dans lequel, pour la deuxième fois, l'espacement de sous-porteuse du signal est supposé être une deuxième valeur qui est différente de la première valeur.

7. Le procédé selon l'une quelconque des revendications 2 à 6 comprenant en outre : le calcul de la corrélation de préfixe cyclique du signal à la fréquence centrale du signal comme une corrélation mobile.

8. Le procédé selon l'une quelconque des revendications 2 à 7 comprenant en outre : l'identification des valeurs de sortie de crête quadratiques maximales à partir de la corrélation de préfixe cyclique pour identifier les limites globales de symbole OFDM.

9. Le procédé selon l'une quelconque des revendications précédentes, dans lequel le canal radio sans fil comprend un canal radio 5G.

10. Le procédé selon l'une quelconque des revendications précédentes comprenant en outre : l'identification des bords de fréquence du signal à partir de la mesure de l'énergie du signal de liaison descendante.

11. Un système comprenant :

un émetteur-récepteur radiofréquence ; et
un processeur programmable,
dans lequel l'émetteur-récepteur radiofréquence reçoit un signal diffusé sur un canal radio sans fil, et
dans lequel le processeur programmable mesure l'énergie du signal de liaison descendante sur une largeur de bande du canal radio sans fil pour identifier une fréquence centrale du signal, traite le signal à la fréquence centrale du signal pour identifier un premier d'une pluralité de blocs de signaux de synchronisation et des limites globales de symbole OFDM pour le canal radio sans fil, et utilise les limites globales de symbole OFDM pour toutes les fréquences de trame du canal radio sans fil pour identifier les blocs restants de la pluralité de blocs de signaux de synchronisation.

12. Le système selon la revendication 11, dans lequel le processeur programmable calcule une corrélation de préfixe cyclique du signal à la fréquence centrale du signal pour identifier le premier de la pluralité de blocs de signaux de synchronisation et les limites globales de symbole OFDM, dans lequel le processeur programmable calcule une corrélation de signal de synchronisation primaire aux limites globales de symbole OFDM pour toutes les fréquences de trame pour identifier les blocs restants de la pluralité de blocs de signaux de synchronisation, et dans lequel le processeur programmable effectue une corrélation de signal de synchronisation secondaire à des valeurs de crête pour des résultats de la corrélation de signal de synchronisation primaire pour toutes les fréquences de trame.

13. Le système selon la revendication 12, dans lequel le processeur programmable effectue une corrélation de signal de référence de démodulation - DM-RS - aux limites globales de symbole OFDM pour toutes les fréquences de trame pour identifier des estimations de canal, et dans lequel le processeur programmable effectue un décodage et une démodulation de bloc d'informations maître - MIB - sur les estimations de canal.

14. Le système selon la revendication 12 ou 13, dans lequel le processeur programmable calcule la corrélation de signal de synchronisation primaire aux limites globales de symbole OFDM pour toutes les fréquences de trame en calculant la corrélation de signal de synchronisation primaire sur chacune des limites de symbole OFDM pour toutes les fréquences de trame une première fois et en calculant la corrélation de signal de synchronisation primaire sur chacune des limites de symbole OFDM pour toutes les fréquences de trame une deuxième fois, dans lequel, pour la première fois, les limites globales de symbole OFDM pour toutes les fréquences de trame sont supposées indiquer un premier symbole OFDM dans une demi-sous-trame du signal, et dans lequel, pour la deuxième fois, les limites globales de symbole OFDM pour toutes les fréquences de trame ne sont pas supposées indiquer le premier symbole OFDM dans la demi-sous-trame du signal.

15. Le système selon la revendication 12, 13 ou 14, dans lequel le processeur programmable calcule la corrélation de préfixe cyclique du signal à la fréquence centrale du signal en calculant la corrélation de préfixe cyclique du signal à la fréquence centrale du signal une première fois, en calculant la corrélation de préfixe cyclique du signal à la fréquence centrale du signal une deuxième fois, et en sélectionnant un résultat de la corrélation de préfixe cyclique avec une valeur de corrélation la plus élevée à utiliser pour identifier le premier de la pluralité de blocs de signaux de synchronisation et les limites globales de symbole OFDM, dans lequel, pour la première fois, un espacement de sous-porteuse du signal est supposé être une première valeur, dans lequel, pour la deuxième fois, l'espacement de sous-porteuse du signal est supposé être une deuxième valeur qui est différente de la première valeur, dans lequel le processeur programmable calcule la corrélation de préfixe cyclique du signal à la fréquence centrale du signal comme une corrélation mobile, et dans lequel le processeur programmable identifie les valeurs de sortie de crête quadratiques maximales à partir de la corrélation de préfixe cyclique pour identifier les limites globales de symbole OFDM.

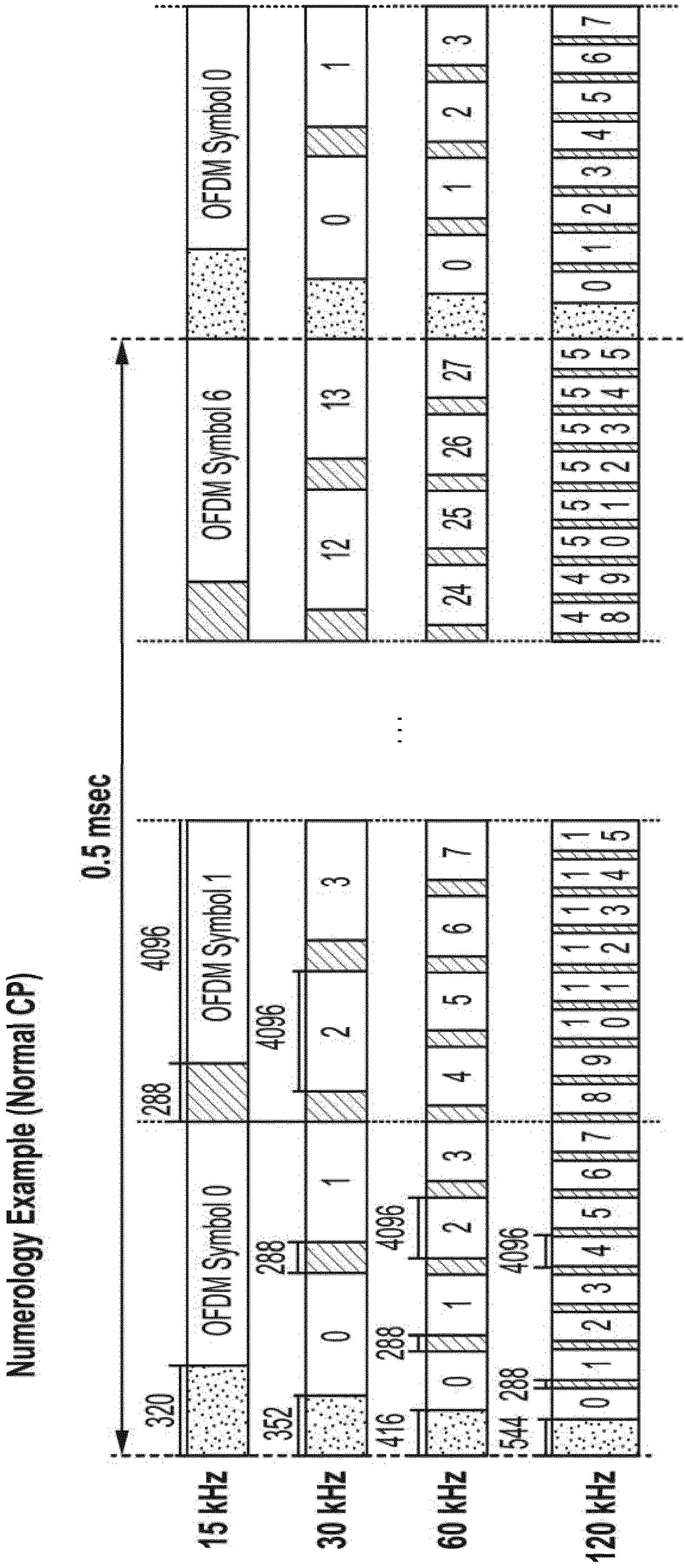

FIG. 1
PRIOR ART

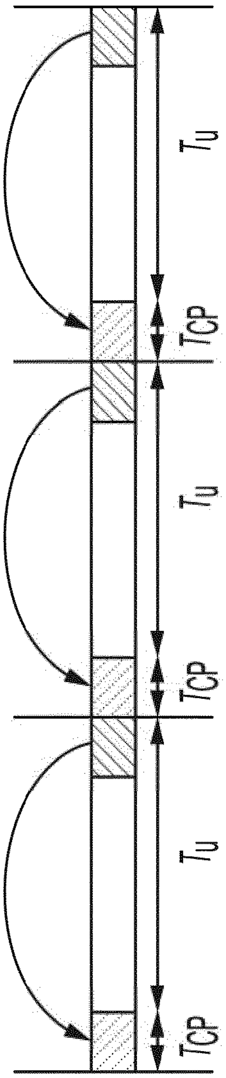

FIG. 2
PRIOR ART

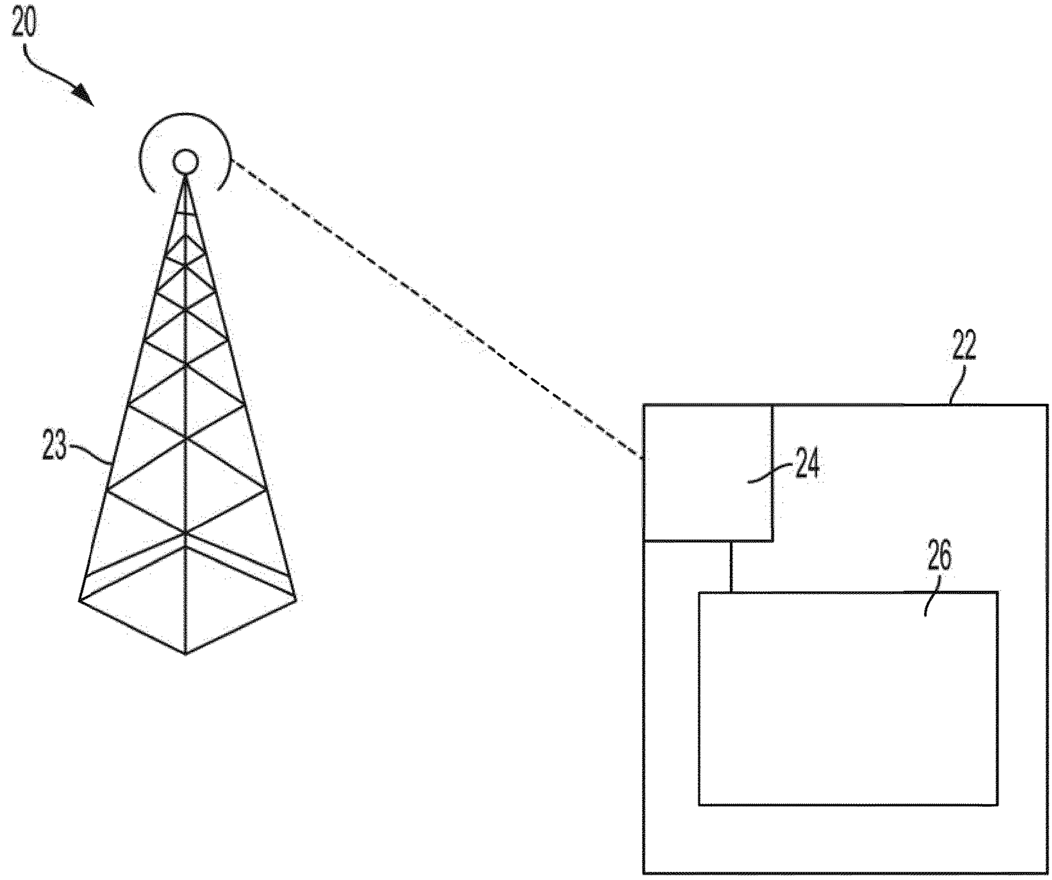

FIG. 3

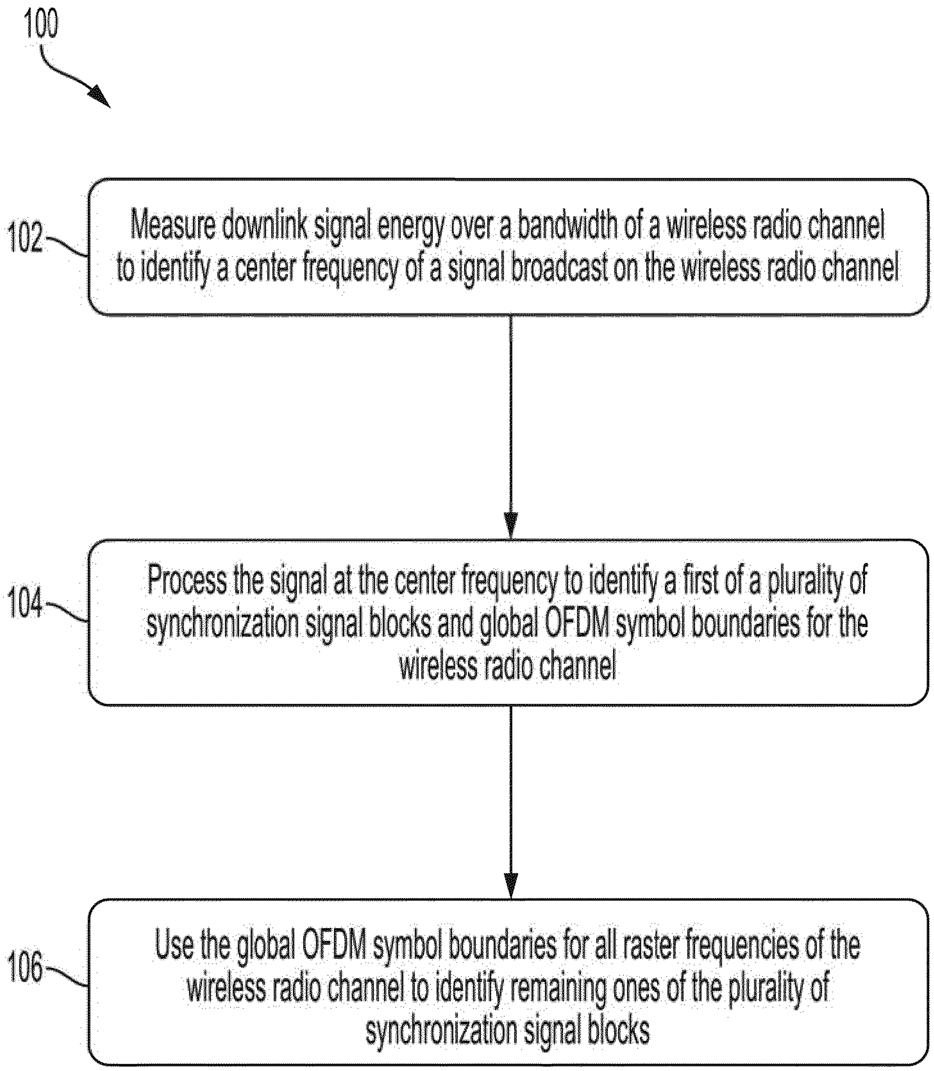
100
102
Measure downlink signal energy over a bandwidth of a wireless radio channel to identify a center frequency of a signal broadcast on the wireless radio channel
104
Process the signal at the center frequency to identify a first of a plurality of synchronization signal blocks and global OFDM symbol boundaries for the wireless radio channel
106
Use the global OFDM symbol boundaries for all raster frequencies of the wireless radio channel to identify remaining ones of the plurality of synchronization signal blocks

FIG. 4

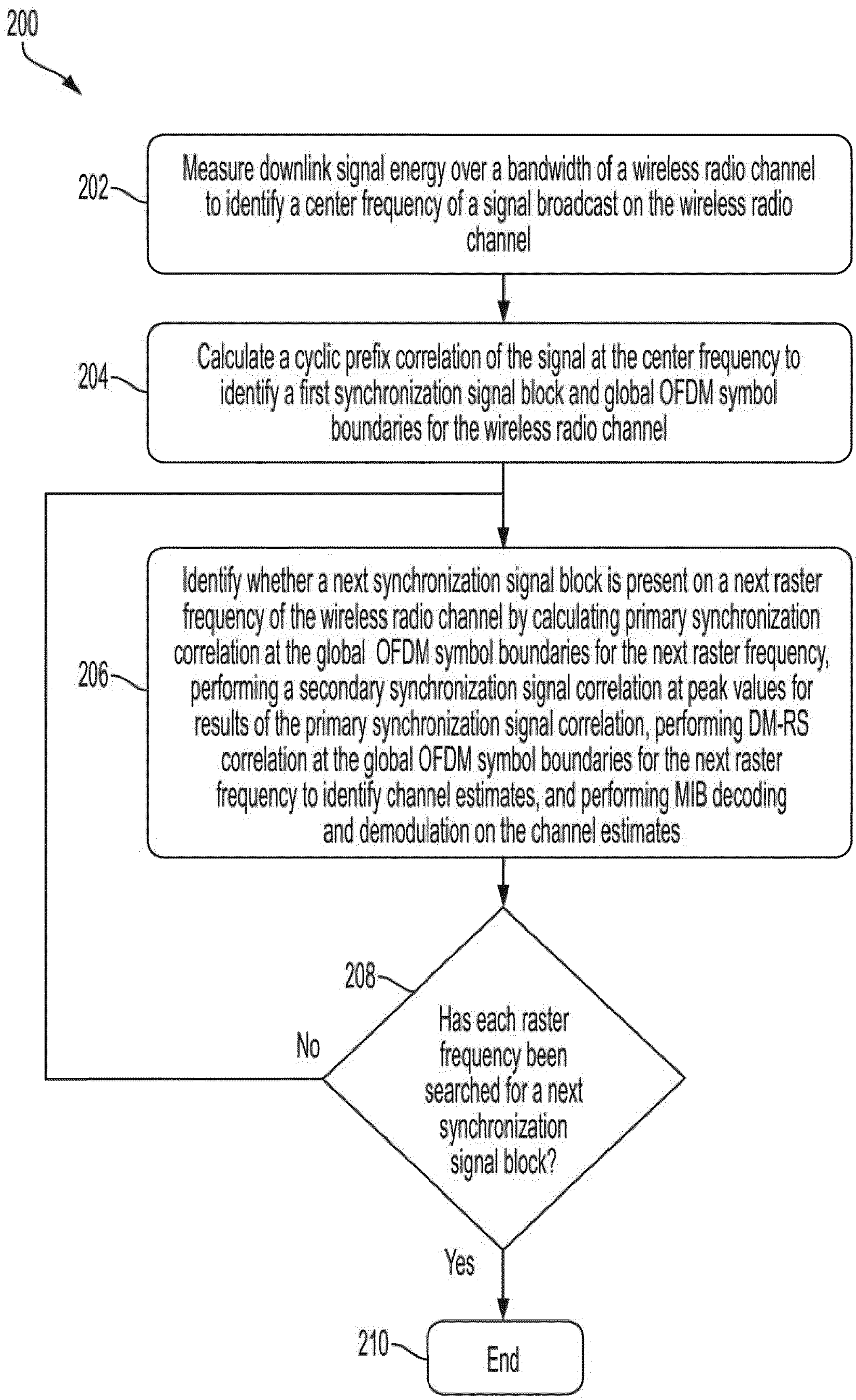
200
202
Measure downlink signal energy over a bandwidth of a wireless radio channel to identify a center frequency of a signal broadcast on the wireless radio channel
204
Calculate a cyclic prefix correlation of the signal at the center frequency to identify a first synchronization signal block and global OFDM symbol boundaries for the wireless radio channel
206
Identify whether a next synchronization signal block is present on a next raster frequency of the wireless radio channel by calculating primary synchronization correlation at the global OFDM symbol boundaries for the next raster frequency, performing a secondary synchronization signal correlation at peak values for results of the primary synchronization signal correlation, performing DM-RS correlation at the global OFDM symbol boundaries for the next raster frequency to identify channel estimates, and performing MIB decoding and demodulation on the channel estimates
208
Has each raster frequency been searched for a next synchronization signal block?
No
Yes
210
End

FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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Non-patent literature cited in the description

- Remaining details on SS block transmissions. *3GPP DRAFT; R1-1720853,* 01 November 2017 **[0003]**