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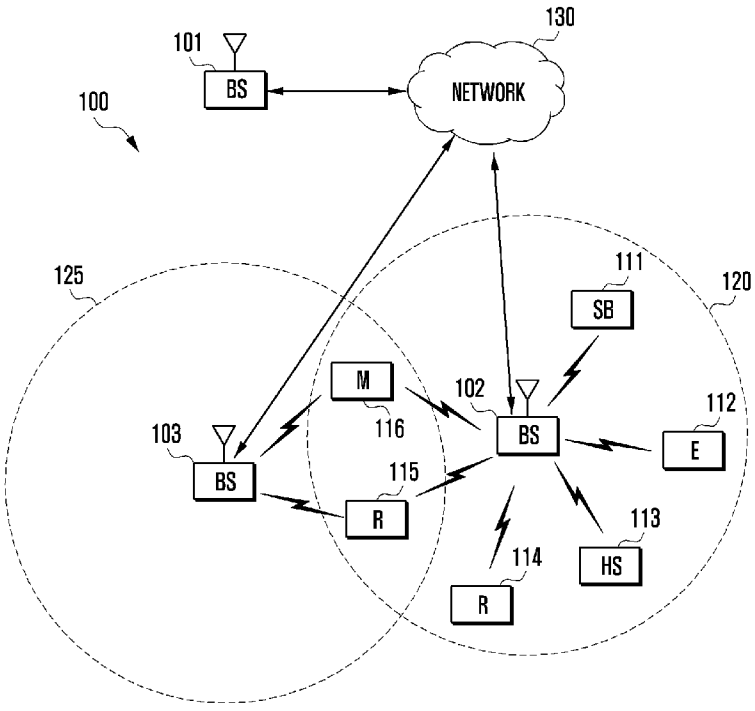

(57) Abstract: The disclosure relates to a 5G or 6G communication system for supporting a higher data transmission rate. The disclosure provides a method performed by a user equipment (UE) in a communication system, comprising: monitoring a wake up signal; waking up the UE after the wake up signal is monitored, wherein the wake up signal comprises a first wake up signal and/or a second wake up signal, the first wake up signal comprises a first synchronization signal for a cell, or comprises the first synchronization signal for the cell and a first data signal, the second wake up signal comprises a second synchronization signal for the cell and/or a second data signal for a UE group.

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Description

Title of Invention: COMMUNICATION METHOD AND COMMUNICATION DEVICE

Technical Field

[1] The present disclosure relates to wireless communication, and more particularly, to communication using a wake-up signal.

Background Art

[2] 5G mobile communication technologies define broad frequency bands such that high transmission rates and new services are possible, and can be implemented not only in "Sub 6GHz" bands such as 3.5GHz, but also in "Above 6GHz" bands referred to as mmWave including 28GHz and 39GHz. In addition, it has been considered to implement 6G mobile communication technologies (referred to as Beyond 5G systems) in terahertz bands (for example, 95GHz to 3THz bands) in order to accomplish transmission rates fifty times faster than 5G mobile communication technologies and ultra-low latencies one-tenth of 5G mobile communication technologies.

[3] At the beginning of the development of 5G mobile communication technologies, in order to support services and to satisfy performance requirements in connection with enhanced Mobile BroadBand (eMBB), Ultra Reliable Low Latency Communications (URLLC), and massive Machine-Type Communications (mMTC), there has been ongoing standardization regarding beamforming and massive MIMO for mitigating radio-wave path loss and increasing radio-wave transmission distances in mmWave, supporting numerologies (for example, operating multiple subcarrier spacings) for efficiently utilizing mmWave resources and dynamic operation of slot formats, initial access technologies for supporting multi-beam transmission and broadbands, definition and operation of BWP (BandWidth Part), new channel coding methods such as a LDPC (Low Density Parity Check) code for large amount of data transmission and a polar code for highly reliable transmission of control information, L2 pre-processing, and network slicing for providing a dedicated network specialized to a specific service.

[4] Currently, there are ongoing discussions regarding improvement and performance enhancement of initial 5G mobile communication technologies in view of services to be supported by 5G mobile communication technologies, and there has been physical layer standardization regarding technologies such as V2X (Vehicle-to-everything) for aiding driving determination by autonomous vehicles based on information regarding positions and states of vehicles transmitted by the vehicles and for enhancing user convenience, NR-U (New Radio Unlicensed) aimed at system operations conforming to various regulation-related requirements in unlicensed bands, NR UE Power Saving,

Non-Terrestrial Network (NTN) which is UE-satellite direct communication for providing coverage in an area in which communication with terrestrial networks is unavailable, and positioning.

[5] Moreover, there has been ongoing standardization in air interface architecture/protocol regarding technologies such as Industrial Internet of Things (IIoT) for supporting new services through interworking and convergence with other industries, IAB (Integrated Access and Backhaul) for providing a node for network service area expansion by supporting a wireless backhaul link and an access link in an integrated manner, mobility enhancement including conditional handover and DAPS (Dual Active Protocol Stack) handover, and two-step random access for simplifying random access procedures (2-step RACH for NR). There also has been ongoing standardization in system architecture/service regarding a 5G baseline architecture (for example, service based architecture or service based interface) for combining Network Functions Virtualization (NFV) and Software-Defined Networking (SDN) technologies, and Mobile Edge Computing (MEC) for receiving services based on UE positions.

[6] As 5G mobile communication systems are commercialized, connected devices that have been exponentially increasing will be connected to communication networks, and it is accordingly expected that enhanced functions and performances of 5G mobile communication systems and integrated operations of connected devices will be necessary. To this end, new research is scheduled in connection with eXtended Reality (XR) for efficiently supporting AR (Augmented Reality), VR (Virtual Reality), MR (Mixed Reality) and the like, 5G performance improvement and complexity reduction by utilizing Artificial Intelligence (AI) and Machine Learning (ML), AI service support, metaverse service support, and drone communication.

[7] Furthermore, such development of 5G mobile communication systems will serve as a basis for developing not only new waveforms for providing coverage in terahertz bands of 6G mobile communication technologies, multi-antenna transmission technologies such as Full Dimensional MIMO (FD-MIMO), array antennas and large-scale antennas, metamaterial-based lenses and antennas for improving coverage of terahertz band signals, high-dimensional space multiplexing technology using OAM (Orbital Angular Momentum), and RIS (Reconfigurable Intelligent Surface), but also full-duplex technology for increasing frequency efficiency of 6G mobile communication technologies and improving system networks, AI-based communication technology for implementing system optimization by utilizing satellites and AI (Artificial Intelligence) from the design stage and internalizing end-to-end AI support functions, and next-generation distributed computing technology for implementing services at levels of complexity exceeding the limit of UE operation capability by utilizing ultra-high-performance communication and computing resources.

[8] In order to meet the increasing demand for wireless data communication services since the deployment of 4G communication systems, efforts have been made to develop improved 5G or pre-5G communication systems. Therefore, 5G or pre-5G communication systems are also called "Beyond 4G networks" or "Post-LTE systems".

[9] 5G communication systems are implemented in higher frequency (mmWave) bands, e.g., 60 GHz bands to achieve a higher data rate. In order to reduce propagation loss of radio waves and increase a transmission distance, technologies such as beamforming, massive multiple-input multiple-output (MIMO), full-dimensional MIMO (FD-MIMO), array antenna, analog beamforming and large-scale antenna are discussed in 5G communication systems.

[10] In addition, in 5G communication systems, developments of system network improvement are underway based on advanced small cell, cloud radio access network (RAN), ultra-dense network, device-to-device (D2D) communication, wireless backhaul, mobile network, cooperative communication, coordinated multi-points (CoMP), reception-end interference cancellation, etc.

[11] In 5G systems, hybrid FSK and QAM modulation (FQAM) and sliding window superposition coding (SWSC) as advanced coding modulation (ACM), and filter bank multicarrier (FBMC), non-orthogonal multiple access (NOMA) and sparse code multiple access (SCMA) as advanced access technologies have been developed.

Disclosure of Invention

Technical Problem

[12] In some use cases (such as Internet of Things devices and/or wearable devices) that require more stringent low power consumption of the UE, in order to further extend the battery life of the UE, the wireless communication system can use a new wake up signal (for example, it can be called a Low Power Wake Up Signal (LPWUS)) to wake up the UE. In this case, the structure, function, configuration and/or monitoring method of the wake up signal are problems to be solved.

Solution to Problem

[13] According to an embodiment of the disclosure, a method performed by a user equipment (UE) in a communication system is provided, including: monitoring a wake up signal; waking up the UE after the wake up signal is monitored, wherein the wake up signal comprises a first wake up signal and/or a second wake up signal, the first wake up signal comprises a first synchronization signal for a cell, or comprises the first synchronization signal for the cell and a first data signal, the second wake up signal comprises a second synchronization signal for the cell and/or a second data signal for a UE group.

[14] In one implementation, wherein the first synchronization signal and the first data

signal are in the same piece of wake up signal; or the UE monitors the first data signal on a first time unit configured by a base station after the first synchronization signal is monitored.

[15] In one implementation, wherein the monitoring of the wake up signal comprises: monitoring the second data signal according to a third cycle configured by a base station.

[16] In one implementation, wherein the first synchronization signal is further for indicating first information, and/or the second synchronization signal is further for indicating the first information, and/or the first data signal is further for indicating the first information, and/or the first data signal comprises the first information; wherein the first information comprises at least one of the followings:

[17] system information modification SystemInfoModification;

[18] earthquake and tsunami warning system and commercial mobile alarm service indication etwsAndCmasIndication;

[19] stop paging monitoring indication information;

[20] a physical cell identification ID;

[21] a beam index;

[22] a tracking area/radio access network RAN area ID;

[23] a system information block SIB message;

[24] a main information block MIB message.

[25] In one implementation, wherein a cycle for the first wake up signal is determined by at least one of the followings: determined based on at least one first cycle configured by a base station; determined based on a modification cycle of the first information; determined based on a cycle of a paging occasion PO or a discontinuous reception DRX cycle; configured by a core network.

[26] In one implementation, wherein the at least one first cycle comprises at least one of 5ms, 10ms, 20ms, 40ms, 80ms, 160ms, 320ms, 640ms and 1280ms.

[27] In one implementation, wherein the cycle for the first wake up signal is one of the at least one first cycle indicated by the SIB.

[28] In one implementation, wherein a cycle for the second synchronization signal is determined by at least one of the followings: determined based on at least one second cycle configured by a base station; determined based on a cycle of a synchronization signal and physical broadcast channel PBCH block SSB; determined based on a cycle of a PO or a DRX cycle; configured by a core network.

[29] In one implementation, wherein the at least one second cycle comprises at least one of 1.25ms, 2.5ms, 5ms, 10ms, 20ms, 40ms, 80ms, and 160ms.

[30] In one implementation, wherein the cycle for the second synchronization signal is one of the at least one second cycle indicated by an SIB.

[31] The method according to an embodiment of the disclosure further comprises: waking up the UE to receive an SSB and/or receive a paging message if the UE does not receive the second synchronization signal within a first time period, wherein a number of time units corresponding to the first time period is configured by a base station or reported to the base station by the UE.

[32] In one implementation, wherein the second data signal comprises part or all of a paging message.

[33] In one implementation, wherein the second data signal comprises at least one of the followings:

[34] list of the paged UEs pagingRecordList;

[35] late non-critical extension lateNonCriticalExtension;

[36] non-critical extension nonCriticalExtension;

[37] system information modification systemInfoModification;

[38] earthquake and tsunami warning system and commercial mobile alarm service indication etwsAndCmasIndication;

[39] stop paging monitoring stopPagingMonitoring indication; and

[40] information about the wake up signal in the next cycle.

[41] In one implementation, wherein the information about the wake up signal in the next cycle comprises a field size of the wake up signal in the next cycle and/or information indicating whether one or more fields exist in the next cycle.

[42] In one implementation, wherein a cycle for the first wake up signal is greater than or equal to a cycle for the second wake up signal.

[43] In one implementation, wherein a frequency domain resource location of the wake up signal is determined by at least one of the followings: determined based on a Point A and a first offset, wherein the point A is obtain by an SSB subcarrier offset and an offset from the Point A OffsetToPointA; a frequency domain starting location of the wake up signal being determined according to a frequency domain location of an SSB; determined according to a frequency band where a PO is located; determined according to a frequency location of search space used for PO monitoring ; determined by blind detection in a global synchronization channel.

[44] In one implementation, wherein a subcarrier space of the wake up signal is at least one of the followings: a subcarrier space indicated by a base station through system information; a first subcarrier space corresponding to frequency domain range 1; a second subcarrier space corresponding to frequency range 2; a third subcarrier space corresponding to frequency domain range 1; a fourth subcarrier space corresponding to frequency range 2; a subcarrier space configured according to a subcarrier space of initial downlink bandwidth part BWP or SSB or CORESET0, wherein the first subcarrier space and the second subcarrier space are both greater than or equal to a first

threshold, wherein the third subcarrier space and the fourth subcarrier space are both smaller than a second threshold.

[45] In one implementation, wherein the wake up signal is modulated based on M-bit frequency shift keying FSK, and carrier frequencies of the M-bit FSK are determined by at least one of the followings: determined according to a central carrier frequency of a frequency band configured by the UE; determined according to a first bandwidth and a first starting frequency domain location of the wake up signal; wherein an interval between adjacent carrier frequencies among the carrier frequencies of the M-bit FSK is greater than or equal to a first threshold value, wherein the first bandwidth, M, the first starting frequency domain location and the first threshold value are reported by the UE or configured by a base station.

[46] The method according to an embodiment of the disclosure further comprises: reporting a modulation mode supported by the UE for the wake up signal to a base station; and receiving a modulation mode for the wake up signal indicated by the base station through an SIB, the monitoring of the wake up signal comprises monitoring the wake up signal based on the indicated modulation mode.

[47] According to an embodiment of the disclosure, a method performed by a base station in a communication system is provided, comprising: transmitting a wake up signal to a UE, wherein the wake up signal is for waking up the UE; transmitting a signal and/or channel to the UE and/or receiving a signal and/or channel from the UE, wherein the wake up signal comprises a first wake up signal and/or a second wake up signal, the first wake up signal comprises a first synchronization signal for a cell, or comprises the first synchronization signal for the cell and a first data signal, the second wake up signal comprises a second synchronization signal for the cell and/or a second data signal for a UE group.

[48] In one implementation, wherein the first synchronization signal and the first data signal are in the same piece of wake up signal; or the base station transmits the first data signal on a first time unit after the first synchronization signal.

[49] In one implementation, the second data signal has a third cycle configured by the base station.

[50] In one implementation, wherein the first synchronization signal is further for indicating first information, and/or the second synchronization signal is further for indicating the first information, and/or the first data signal is further for indicating the first information, and/or the first data signal comprises the first information; wherein the first information comprises at least one of the followings:

[51] system information modification SystemInfoModification;

[52] earthquake and tsunami warning system and commercial mobile alarm service indication etwsAndCmasIndication;

[53] stop paging monitoring indication information;

[54] a physical cell identification ID;

[55] a beam index;

[56] a tracking area/radio access network RAN area ID;

[57] a system information block SIB message;

[58] a main information block MIB message.

[59] In one implementation, wherein a cycle for the first wake up signal is determined by at least one of the followings: determined based on at least one first cycle configured by a base station; determined based on a modification cycle of the first information; determined based on a cycle of a paging occasion PO or a discontinuous reception DRX cycle; configured by a core network.

[60] In one implementation, wherein the at least one first cycle comprises at least one of 5ms, 10ms, 20ms, 40ms, 80ms, 160ms, 320ms, 640ms and 1280m.

[61] In one implementation, wherein the cycle for the first wake up signal is one of the at least one first cycle indicated by the SIB.

[62] In one implementation, wherein a cycle for the second synchronization signal is determined by at least one of the followings: determined based on at least one second cycle configured by a base station; determined based on a cycle of a synchronization signal and physical broadcast channel PBCH block SSB; determined based on a cycle of a PO or a DRX cycle; configured by a core network.

[63] In one implementation, wherein the at least one second cycle comprises at least one of 1.25ms, 2.5ms, 5ms, 10ms, 20ms, 40ms, 80ms, and 160ms.

[64] In one implementation, wherein the cycle for the second synchronization signal is one of the at least one second cycle indicated by an SIB.

[65] The method according to an embodiment of the disclosure further comprises: the base station configures a number of time units, wherein the UE is waked up to receive an SSB and/or receive a paging message if the UE does not receive the second synchronization signal within a first time period corresponding to the number of time units.

[66] In one implementation, wherein the second data signal comprises part or all of a paging message.

[67] In one implementation, wherein the second data signal comprises at least one of the followings:

[68] list of the paged UEs pagingRecordList;

[69] late non-critical extension lateNonCriticalExtension;

[70] non-critical extension nonCriticalExtension;

[71] system information modification systemInfoModification;

[72] earthquake and tsunami warning system and commercial mobile alarm service in-

dication etwsAndCmasIndication;

[73] stop paging monitoring stopPagingMonitoring indication; and

[74] information about the wake up signal in the next cycle.

[75] In one implementation, wherein the information about the wake up signal in the next cycle comprises a field size of the wake up signal in the next cycle and/or information indicating whether one or more fields exist in the next cycle.

[76] In one implementation, wherein a cycle for the first wake up signal is greater than or equal to a cycle for the second wake up signal.

[77] In one implementation, wherein a frequency domain resource location of the wake up signal is determined by at least one of the followings: determined based on a Point A and a first offset, wherein the point A is obtain by an SSB subcarrier offset and an offset from the Point A OffsetToPointA; a frequency domain starting location of the wake up signal being determined according to a frequency domain location of an SSB; determined according to a frequency band where a PO is located; determined according to a frequency location of search space used for PO monitoring; determined by blind detection in a global synchronization channel.

[78] In one implementation, wherein a subcarrier space of the wake up signal is at least one of the followings: a subcarrier space indicated by a base station through system information; a first subcarrier space corresponding to frequency domain range 1; a second subcarrier space corresponding to frequency range 2; a third subcarrier space corresponding to frequency domain range 1; a fourth subcarrier space corresponding to frequency range 2; a subcarrier space configured according to a subcarrier space of initial downlink bandwidth part BWP or SSB or CORESET0, wherein the first subcarrier space and the second subcarrier space are both greater than or equal to a first threshold, wherein the third subcarrier space and the fourth subcarrier space are both smaller than a second threshold.

[79] In one implementation, wherein the wake up signal is modulated based on M-bit frequency shift keying FSK, and carrier frequencies of the M-bit FSK are determined by at least one of the followings: determined according to a central carrier frequency of a frequency band configured by the UE; determined according to a first bandwidth and a first starting frequency domain location of the wake up signal; wherein an interval between adjacent carrier frequencies in the carrier frequencies of the M-bit FSK is greater than or equal to a first threshold value, wherein the first bandwidth, M, the first starting frequency domain location and the first threshold value are reported by the UE or configured by a base station.

[80] The method according to an embodiment of the disclosure further comprises: the base station receives a modulation mode for the wake up signal supported by the UE from the UE; and the base station indicates the modulation mode for the wake up

signal to the UE through the SIB.

[81] According to an embodiment of the disclosure, a user equipment in a communication system is provided, comprising a transceiver configured to transmit and/or receive a signal; and a processor coupled with the transceiver and configured to control to perform the method according to an embodiment of the disclosure.

[82] According to an embodiment of the disclosure, a base station in a communication system is provided, comprising a transceiver configured to transmit and/or receive a signal; and a processor coupled with the transceiver and configured to control to perform the method according to an embodiment of the disclosure.

Advantageous Effects of Invention

[83] In the present invention, a method and device for a low power wake up signal configuration and monitoring will be introduced. In one embodiment of the present invention, a method for determining the structure and function, configuration, and monitoring of the LPWUS will be introduced. In this embodiment, the LPWUS is used for an exemplary introduction, and the introduced method can also be applied for the configuration and transmission of other signals.

Brief Description of Drawings

[84] FIG. 1 illustrates an example wireless network according to various embodiments of the disclosure;

[85] FIG. 2a illustrates an example wireless transmission path according to the disclosure;

[86] FIG. 2b illustrates an example wireless reception path according to the disclosure;

[87] FIG. 3a illustrates an example user equipment UE according to the disclosure;

[88] FIG. 3b illustrates an example gNB according to the disclosure;

[89] FIG. 4 illustrates an example flowchart of a method performed by a UE according to an embodiment of the disclosure;

[90] FIG. 5 illustrates an example flowchart of a method performed by a base station according to an embodiment of the disclosure;

[91] FIG. 6 illustrates an example hardware block diagram of a UE according to an embodiment of the disclosure;

[92] FIG. 7 illustrates an example hardware block diagram of a base station according to an embodiment of the disclosure.

Mode for the Invention

[93] The following description with reference to the accompanying drawings is provided to facilitate a comprehensive understanding of various embodiments of the disclosure as defined by the claims and their equivalents. This description includes various specific details to facilitate understanding but should only be considered as exemplary. Therefore, those skilled in the art will recognize that various changes and modi-

fications may be made to the various embodiments described herein without departing from the scope and spirit of the disclosure. In addition, for the sake of clarity and conciseness, descriptions of well-known functions and structures may be omitted.

[94] The terms and expressions used in the following specification and claims are not limited to their dictionary meanings, but are only used by the inventors to enable a clear and consistent understanding of the disclosure. Therefore, it should be obvious to those skilled in the art that the following descriptions of various embodiments of the disclosure are provided for illustration purposes only and are not intended to limit the purposes of the disclosure as defined in the appended claims and their equivalents.

[95] It should be understood that singular forms of "a", "an" and "the" include plural referents unless the context clearly indicates otherwise. Thus, for example, a reference to a "component surface" includes a reference to one or more such surfaces.

[96] The terms "include" or "may include" refer to the existence of a corresponding disclosed function, operation or component that may be used in various embodiments of the disclosure, without limiting the existence of one or more additional functions, operations or features. In addition, the terms "include" or "have" may be interpreted as indicating certain characteristics, numbers, steps, operations, constituent elements, components or combinations thereof, but should not be interpreted as excluding the possibility of the existence of one or more other characteristics, numbers, steps, operations, constituent elements, components or combinations thereof.

[97] The term "or" used in various embodiments of the disclosure includes any of the listed terms and all combinations thereof. For example, "A or B" may include A, may include B, or may include both A and B.

[98] Unless defined differently, all terms (including technical terms or scientific terms) used in this disclosure have the same meaning as those understood by those skilled in the art in this disclosure. General terms, as defined in dictionaries, are interpreted as having meanings consistent with the context in the relevant technical fields, and should not be interpreted in an idealized or overly formal way unless explicitly defined in this disclosure.

[99] Technical solutions of embodiments of the application may be applied to various communication systems, such as Global System for Mobile Communications (GSM) system, code division multiple access (CDMA) system, wideband code division multiple access (WCDMA) system, general packet radio service (GPRS), long term evolution (LTE) system, LTE frequency division duplex (FDD) system, LTE time division duplex (TDD), universal mobile telecommunications system (UMTS), worldwide interoperability for microwave access (WiMAX) communication system, 5th generation (5G) system or new radio (NR), etc. In addition, the technical solutions of embodiments of the application may be applied to future-oriented communication

technologies.

[100] FIG. 1 illustrates an example wireless network 100 according to various embodiments of the disclosure. The embodiment of the wireless network 100 shown in FIG. 1 is for illustration only. Other embodiments of the wireless network 100 may be used without departing from the scope of the disclosure.

[101] The wireless network 100 includes a gNodeB (gNB) 101, a gNB 102, and a gNB 103. gNB 101 communicates with gNB 102 and gNB 103. gNB 101 also communicates with at least one Internet Protocol (IP) network 130, such as the Internet, a private IP network, or other data networks.

[102] Depending on a type of the network, other well-known terms such as "base station" or "access point" may be used instead of "gNodeB" or "gNB". For convenience, the terms "gNodeB" and "gNB" are used in this patent document to refer to network infrastructure components that provide wireless access for remote terminals. And, depending on the type of the network, other well-known terms such as "mobile station", "user station", "remote terminal", "wireless terminal" or "user apparatus" may be used instead of "user equipment" or "UE". For convenience, the terms "user equipment" and "UE" are used in this patent document to refer to remote wireless devices that wirelessly access the gNB, no matter whether the UE is a mobile device (such as a mobile phone or a smart phone) or a fixed device (such as a desktop computer or a vending machine).

[103] gNB 102 provides wireless broadband access to the network 130 for a first plurality of User Equipments (UEs) within a coverage area 120 of gNB 102. The first plurality of UEs include a UE 111, which may be located in a Small Business (SB); a UE 112, which may be located in an enterprise (E); a UE 113, which may be located in a WiFi Hotspot (HS); a UE 114, which may be located in a first residence (R); a UE 115, which may be located in a second residence (R); a UE 116, which may be a mobile device (M), such as a cellular phone, a wireless laptop computer, a wireless PDA, etc. GNB 103 provides wireless broadband access to network 130 for a second plurality of UEs within a coverage area 125 of gNB 103. The second plurality of UEs include a UE 115 and a UE 116. In some embodiments, one or more of gNBs 101-103 may communicate with each other and with UEs 111-116 using 5G, Long Term Evolution (LTE), LTE-A, WiMAX or other advanced wireless communication technologies.

[104] The dashed lines show approximate ranges of the coverage areas 120 and 125, and the ranges are shown as approximate circles merely for illustration and explanation purposes. It should be clearly understood that the coverage areas associated with the gNBs, such as the coverage areas 120 and 125, may have other shapes, including irregular shapes, depending on configurations of the gNBs and changes in the radio environment associated with natural obstacles and man-made obstacles.

[105] As will be described in more detail below, one or more of gNB 101, gNB 102, and gNB 103 include a 2D antenna array as described in embodiments of the disclosure. In some embodiments, one or more of gNB 101, gNB 102, and gNB 103 support codebook designs and structures for systems with 2D antenna arrays.

[106] Although FIG. 1 illustrates an example of the wireless network 100, various changes may be made to FIG. 1. The wireless network 100 may include any number of gNBs and any number of UEs in any suitable arrangement, for example. Furthermore, gNB 101 may directly communicate with any number of UEs and provide wireless broadband access to the network 130 for those UEs. Similarly, each gNB 102-103 may directly communicate with the network 130 and provide direct wireless broadband access to the network 130 for the UEs. In addition, gNB 101, 102 and/or 103 may provide access to other or additional external networks, such as external telephone networks or other types of data networks.

[107] FIGs. 2a and 2b illustrate example wireless transmission and reception paths according to the disclosure. In the following description, the transmission path 200 may be described as being implemented in a gNB, such as gNB 102, and the reception path 250 may be described as being implemented in a UE, such as UE 116. However, it should be understood that the reception path 250 may be implemented in a gNB and the transmission path 200 may be implemented in a UE. In some embodiments, the reception path 250 is configured to support codebook designs and structures for systems with 2D antenna arrays as described in embodiments of the disclosure.

[108] The transmission path 200 includes a channel coding and modulation block 205, a Serial-to-Parallel (S-to-P) block 210, a size N Inverse Fast Fourier Transform (IFFT) block 215, a Parallel-to-Serial (P-to-S) block 220, a cyclic prefix addition block 225, and an up-converter (UC) 230. The reception path 250 includes a down-converter (DC) 255, a cyclic prefix removal block 260, a Serial-to-Parallel (S-to-P) block 265, a size N Fast Fourier Transform (FFT) block 270, a Parallel-to-Serial (P-to-S) block 275, and a channel decoding and demodulation block 280.

[109] In the transmission path 200, the channel coding and modulation block 205 receives a set of information bits, applies coding (such as Low Density Parity Check (LDPC) coding), and modulates the input bits (such as using Quadrature Phase Shift Keying (QPSK) or Quadrature Amplitude Modulation (QAM)) to generate a sequence of frequency-domain modulated symbols. The Serial-to-Parallel (S-to-P) block 210 converts (such as demultiplexes) serial modulated symbols into parallel data to generate N parallel symbol streams, where N is a size of the IFFT/FFT used in gNB 102 and UE 116. The size N IFFT block 215 performs IFFT operations on the N parallel symbol streams to generate a time-domain output signal. The Parallel-to-Serial block 220 converts (such as multiplexes) parallel time-domain output symbols from

the Size N IFFT block 215 to generate a serial time-domain signal. The cyclic prefix addition block 225 inserts a cyclic prefix into the time-domain signal. The up-converter 230 modulates (such as up-converts) the output of the cyclic prefix addition block 225 to an RF frequency for transmission via a wireless channel. The signal may also be filtered at a baseband before switching to the RF frequency.

[110] The RF signal transmitted from gNB 102 arrives at UE 116 after passing through the wireless channel, and operations in reverse to those at gNB 102 are performed at UE 116. The down-converter 255 down-converts the received signal to a baseband frequency, and the cyclic prefix removal block 260 removes the cyclic prefix to generate a serial time-domain baseband signal. The Serial-to-Parallel block 265 converts the time-domain baseband signal into a parallel time-domain signal. The Size N FFT block 270 performs an FFT algorithm to generate N parallel frequency-domain signals. The Parallel-to-Serial block 275 converts the parallel frequency-domain signal into a sequence of modulated data symbols. The channel decoding and demodulation block 280 demodulates and decodes the modulated symbols to recover the original input data stream.

[111] Each of gNBs 101-103 may implement a transmission path 200 similar to that for transmitting to UEs 111-116 in the downlink, and may implement a reception path 250 similar to that for receiving from UEs 111-116 in the uplink. Similarly, each of UEs 111-116 may implement a transmission path 200 for transmitting to gNBs 101-103 in the uplink, and may implement a reception path 250 for receiving from gNBs 101-103 in the downlink.

[112] Each of the components in FIGs. 2a and 2b may be implemented using only hardware, or using a combination of hardware and software/firmware. As a specific example, at least some of the components in FIGs. 2a and 2b may be implemented in software, while other components may be implemented in configurable hardware or a combination of software and configurable hardware. For example, the FFT block 270 and IFFT block 215 may be implemented as configurable software algorithms, in which the value of the size N may be modified according to the implementation.

[113] Furthermore, although described as using FFT and IFFT, this is only illustrative and should not be interpreted as limiting the scope of the disclosure. Other types of transforms may be used, such as Discrete Fourier transform (DFT) and Inverse Discrete Fourier Transform (IDFT) functions. It should be understood that for DFT and IDFT functions, the value of variable N may be any integer (such as 1, 2, 3, 4, etc.), while for FFT and IFFT functions, the value of variable N may be any integer which is a power of 2 (such as 1, 2, 4, 8, 16, etc.).

[114] Although FIGs. 2a and 2b illustrate examples of wireless transmission and reception paths, various changes may be made to FIGs. 2a and 2b. For example, various

components in FIGs. 2a and 2b may be combined, further subdivided or omitted, and additional components may be added according to specific requirements. Furthermore, FIGs. 2a and 2b are intended to illustrate examples of types of transmission and reception paths that may be used in a wireless network. Any other suitable architecture may be used to support wireless communication in a wireless network.

[115] FIG. 3a illustrates an example UE 116 according to the disclosure. The embodiment of UE 116 shown in FIG. 3a is for illustration only, and UEs 111-115 of FIG. 1 may have the same or similar configuration. However, a UE has various configurations, and FIG. 3a does not limit the scope of the disclosure to any specific implementation of the UE.

[116] UE 116 includes an antenna 305, a radio frequency (RF) transceiver 310, a transmission (TX) processing circuit 315, a microphone 320, and a reception (RX) processing circuit 325. UE 116 also includes a speaker 330, a processor/controller 340, an input/output (I/O) interface 345, an input device(s) 350, a display 355, and a memory 360. The memory 360 includes an operating system (OS) 361 and one or more applications 362.

[117] The RF transceiver 310 receives an incoming RF signal transmitted by a gNB of the wireless network 100 from the antenna 305. The RF transceiver 310 down-converts the incoming RF signal to generate an intermediate frequency (IF) or baseband signal. The IF or baseband signal is transmitted to the RX processing circuit 325, where the RX processing circuit 325 generates a processed baseband signal by filtering, decoding and/or digitizing the baseband or IF signal. The RX processing circuit 325 transmits the processed baseband signal to speaker 330 (such as for voice data) or to processor/ controller 340 for further processing (such as for web browsing data).

[118] The TX processing circuit 315 receives analog or digital voice data from microphone 320 or other outgoing baseband data (such as network data, email or interactivated video game data) from processor/controller 340. The TX processing circuit 315 encodes, multiplexes, and/or digitizes the outgoing baseband data to generate a processed baseband or IF signal. The RF transceiver 310 receives the outgoing processed baseband or IF signal from the TX processing circuit 315 and up-converts the baseband or IF signal into an RF signal transmitted via the antenna 305.

[119] The processor/controller 340 may include one or more processors or other processing devices and perform an OS 361 stored in the memory 360 in order to control the overall operation of UE 116. For example, the processor/controller 340 may control the reception of forward channel signals and the transmission of backward channel signals through the RF transceiver 310, the RX processing circuit 325 and the TX processing circuit 315 according to well-known principles. In some embodiments, the processor/ controller 340 includes at least one microprocessor or microcontroller.

[120] The processor/controller 340 is also capable of executing other processes and programs residing in the memory 360, such as operations for channel quality measurement and reporting for systems with 2D antenna arrays as described in embodiments of the disclosure. The processor/controller 340 may move data into or out of the memory 360 as required by an execution process. In some embodiments, the processor/controller 340 is configured to perform the application 362 based on the OS 361 or in response to signals received from the gNB or the operator. The processor/controller 340 is also coupled to an I/O interface 345, where the I/O interface 345 provides UE 116 with the ability to connect to other devices such as laptop computers and handheld computers. I/O interface 345 is a communication path between these accessories and the processor/controller 340.

[121] The processor/controller 340 is also coupled to the input device(s) 350 and the display 355. An operator of UE 116 may input data into UE 116 using the input device(s) 350. The display 355 may be a liquid crystal display or other display capable of presenting text and/or at least limited graphics (such as from a website). The memory 360 is coupled to the processor/controller 340. A part of the memory 360 may include a random access memory (RAM), while another part of the memory 360 may include a flash memory or other read-only memory (ROM).

[122] Although FIG. 3a illustrates an example of UE 116, various changes may be made to FIG. 3a. For example, various components in FIG. 3a may be combined, further subdivided or omitted, and additional components may be added according to specific requirements. As a specific example, the processor/controller 340 may be divided into a plurality of processors, such as one or more central processing units (CPUs) and one or more graphics processing units (GPUs). Furthermore, although FIG. 3a illustrates that the UE 116 is configured as a mobile phone or a smart phone, UEs may be configured to operate as other types of mobile or fixed devices.

[123] FIG. 3b illustrates an example gNB 102 according to the disclosure. The embodiment of gNB 102 shown in FIG. 3b is for illustration only, and other gNBs of FIG. 1 may have the same or similar configuration. However, a gNB has various configurations, and FIG. 3b does not limit the scope of the disclosure to any specific implementation of a gNB. It should be noted that gNB 101 and gNB 103 may include the same or similar structures as gNB 102.

[124] As shown in FIG. 3b, gNB 102 includes a plurality of antennas 370a-370n, a plurality of RF transceivers 372A-372n, a transmission (TX) processing circuit 374, and a reception (RX) processing circuit 376. In certain embodiments, one or more of the plurality of antennas 370a-370n include a 2D antenna array. gNB 102 also includes a controller/processor 378, a memory 380, and a backhaul or network interface 382.

[125] RF transceivers 372A-372n receive an incoming RF signal from antennas 370a-370n,

such as a signal transmitted by UEs or other gNBs. RF transceivers 372A-372n down-convert the incoming RF signal to generate an IF or baseband signal. The IF or baseband signal is transmitted to the RX processing circuit 376, where the RX processing circuit 376 generates a processed baseband signal by filtering, decoding and/or digitizing the baseband or IF signal. RX processing circuit 376 transmits the processed baseband signal to controller/processor 378 for further processing.

[126] The TX processing circuit 374 receives analog or digital data (such as voice data, network data, email or interactivated video game data) from the controller/processor 378. TX processing circuit 374 encodes, multiplexes and/or digitizes outgoing baseband data to generate a processed baseband or IF signal. RF transceivers 372A-372n receive the outgoing processed baseband or IF signal from TX processing circuit 374 and up-convert the baseband or IF signal into an RF signal transmitted via antennas 370a-370n.

[127] The controller/processor 378 may include one or more processors or other processing devices that control the overall operation of gNB 102. For example, the controller/ processor 378 may control the reception of forward channel signals and the transmission of backward channel signals through the RF transceivers 372A-372n, the RX processing circuit 376 and the TX processing circuit 374 according to well-known principles. The controller/processor 378 may also support additional functions, such as higher-level wireless communication functions. For example, the controller/processor 378 may perform a Blind Interference Sensing (BIS) process such as that performed through a BIS algorithm, and decode a received signal from which an interference signal is subtracted. A controller/processor 378 may support any of a variety of other functions in gNB 102. In some embodiments, the controller/processor 378 includes at least one microprocessor or microcontroller.

[128] The controller/processor 378 is also capable of executing programs and other processes residing in the memory 380, such as a basic OS. The controller/processor 378 may also support channel quality measurement and reporting for systems with 2D antenna arrays as described in embodiments of the disclosure. In some embodiments, the controller/processor 378 supports communication between entities such as web RTCs. The controller/processor 378 may move data into or out of the memory 380 as required by an execution process.

[129] The controller/processor 378 is also coupled to the backhaul or network interface 382. The backhaul or network interface 382 allows gNB 102 to communicate with other devices or systems through a backhaul connection or through a network. The backhaul or network interface 382 may support communication over any suitable wired or wireless connection(s). For example, when gNB 102 is implemented as a part of a cellular communication system, such as a cellular communication system

supporting 5G or new radio access technology or NR, LTE or LTE-A, the backhaul or network interface 382 may allow gNB 102 to communicate with other gNBs through wired or wireless backhaul connections. When gNB 102 is implemented as an access point, the backhaul or network interface 382 may allow gNB 102 to communicate with a larger network, such as the Internet, through a wired or wireless local area network or through a wired or wireless connection. The backhaul or network interface 382 includes any suitable structure that supports communication through a wired or wireless connection, such as an Ethernet or an RF transceiver.

[130] The memory 380 is coupled to the controller/processor 378. A part of the memory 380 may include a RAM, while another part of the memory 380 may include a flash memory or other ROMs. In certain embodiments, a plurality of indication, such as the BIS algorithm, are stored in the memory. The plurality of indication are configured to cause the controller/processor 378 to perform the BIS process and decode the received signal after subtracting at least one interference signal determined by the BIS algorithm.

[131] As will be described in more detail below, the transmission and reception paths of gNB 102 (implemented using RF transceivers 372A-372n, TX processing circuit 374 and/or RX processing circuit 376) support aggregated communication with FDD cells and TDD cells.

[132] Although FIG. 3b illustrates an example of gNB 102, various changes may be made to FIG. 3b. For example, gNB 102 may include any number of each component shown in FIG. 3a. As a specific example, the access point may include many backhaul or network interfaces 382, and the controller/processor 378 may support routing functions to route data between different network addresses. As another specific example, although shown as including a single instance of the TX processing circuit 374 and a single instance of the RX processing circuit 376, gNB 102 may include multiple instances of each (such as one for each RF transceiver).

[133] Exemplary embodiments of the disclosure are further described below with reference to the accompanying drawings.

[134] Text and drawings are provided as examples only to help readers understand the disclosure. They are not intended and should not be construed to limit the scope of the disclosure in any way. Although certain embodiments and examples have been provided, based on the disclosure herein, it is obvious to those skilled in the art that changes may be made to the illustrated embodiments and examples without departing from the scope of this disclosure.

[135] A time domain unit (also called a time unit) in the application may be: an OFDM symbol, an OFDM symbol group (composed of multiple OFDM symbols), a time slot, a time slot group (composed of multiple time slots), a subframe, a subframe group

(composed of multiple subframes), a system frame and a system frame group (composed of multiple system frames); it may also be an absolute time unit, such as 1 millisecond, 1 second, etc.; the time unit may also be a combination of various granularities, such as N1 time slots plus N2 OFDM symbols.

[136] A frequency domain unit (also called a frequency unit) in the application may be a subcarrier, a subcarrier group (composed of multiple subcarriers), a resource block (RB) (also called a physical resource block (PRB)), a resource block group (composed of multiple RBs), a bandwidth part (BWP), a bandwidth part group (composed of multiple BWPs), a frequency band/carrier, a frequency band group/carrier group; it may also be an absolute frequency domain unit, such as 1 Hz, 1 kHz, etc.; the frequency domain unit may also be a combination of multiple granularities, such as M1 PRBs plus M2 subcarriers.

[137] Exemplary embodiments of the disclosure are further described below with reference to the accompanying drawings.

[138] Text and drawings are provided as examples only to help readers understand the disclosure. They are not intended and should not be construed to limit the scope of the disclosure in any way. Although certain embodiments and examples have been provided, based on the disclosure herein, it is obvious to those skilled in the art that changes may be made to the illustrated embodiments and examples without departing from the scope of this disclosure.

[139] Transmission links of a wireless communication system mainly includes: a downlink communication link from a 5G New Radio (NR) gNB to a User Equipment (UE), and an uplink communication link from a UE to a network, and a sidelink communication link from a UE to a UE.

[140] In a wireless communication system, such as the current wireless communication system, in order to reduce energy consumption at a terminal side, a Discontinuous Reception (DRX) mechanism is introduced, such that a UE may be in a sleep state most of the time, and only needs to be waked up periodically to monitor a Paging Occasion (PO). In a DRX cycle, the UE only be waked up to monitor the PO during a DRX ON duration, and after a PDCCH scrambled with P-RNTI is monitored, the UE continues to read a paged terminal identifier in a paging message, the UE further reads the paging message if the read terminal identifier is the same as its own identifier, otherwise discards the paging message. In the above procedure, in order to further reduce energy consumption of the UE, a paging early indication (PEI) signal is introduced to indicate whether the UE needs to monitor the corresponding PO. If PEI configuration is provided in system information , the UE can monitor one PEI occasion perDRX cycle, if the UE detects PEI indication and the PEI indicates the UE to monitor its associated PO, the UE should wake up at the next PO to monitor the PO;

otherwise, the UE is not required to wake up to monitor the PO.

[141] In RRC connection state, each DRX cycle includes an Active Time and a Non-active Time, in the Active Time, the UE needs to monitor PDCCH, while in the Non-active Time, the UE does not need to monitor the PDCCH, UE starts a drx-onDurationTimer (DRX ON duration timer) at the beginning of each DRX cycle to start PDCCH monitoring , in the transmission process, if the UE monitors Downlink Control Information (DCI) for scheduling new data transmission, the UE starts a drx-inactivityTimer (DRX inactivity timer). During the DRX Active Time, a base station can signal the UE to enter the DRX Non-active Time in advance, or when all the DRX timers of the UE stop running, the UE can enter the DRX Non-active Time.

[142] In some use cases (such as Internet of Things devices and/or wearable devices) that require more stringent low power consumption of the UE, in order to further extend the battery life of the UE, the wireless communication system can use a new wake up signal (for example, it can be called a Low Power Wake Up Signal (LPWUS)) to wake up the UE. In this case, the structure, function, configuration and/or monitoring method of the wake up signal are problems to be solved.

[143] It should be understood that for simplicity of description, descriptions of low power-consumption wake up signal, low power wake up signal, LPWUS, LP-WUS, etc. are used throughout description of the application, but these names are only exemplary and are not intended to limit the names of the wake up signal to which the application applies. Rather, such a wake up signal may also have other names, as long as it may implement functions that the wake up signal (for example, LPWUS) described in this disclosure may implement, it falls within the scope of this disclosure.

[144] In the present invention, a method and device for a low power wake up signal configuration and monitoring will be introduced. In one embodiment of the present invention, a method for determining the structure and function, configuration, and monitoring of the LPWUS will be introduced. In this embodiment, the LPWUS is used for an exemplary introduction, and the introduced method can also be applied for the configuration and transmission of other signals.

[145] For example, a receiver of a UE may include two modules, one is a module for receiving a conventional signal/channel transmitted by a base station, for example, a primary communication receiver (PCR); and the other is a module for receiving the LPWUS transmitted by the base station, for example, a lower power wake up signal receiver (LPWUR). The reason why the above-mentioned dedicated module is used to receive the LPWUS is because the LPWUS is based on the waveform modulated by amplitude shift keying (ASK) and/or frequency shift keying (FSK), that is, different from the waveform based on orthogonal frequency division multiplexing (OFDM) system of the existing NR system, the LPWUR may monitor the LPWUS with

extremely low power. Once the UE monitors the LPWUS, the LPWUR may trigger the primary communication receiver (PCR) to switch from dormant time to Active Time, so that specific operations may be performed. Optionally, on-off keying (OOK) modulation is a special case of amplitude shift keying (ASK) modulation.

[146] According to an embodiment of the disclosure, the wake up signal may include a first wake up signal and/or a second wake up signal.

[147] In one implementation, the first wake up signal may include a first synchronization signal, or the first wake up signal may include the first synchronization signal and a first data signal. In case that the first wake up signal includes the first synchronization signal and the first data signal, the first synchronization signal and the first data signal are configured together by the base station, or it may be understood that there is a correlation between the first synchronization signal and the first data signal, for example, the corresponding first data signal may be transmitted after the first synchronization signal. Or, the first synchronization signal may be transmitted together with the first data signal. The first wake up signal may be used to wake up all UEs in a cell to receive specific information (for example, "first information" described below) for all users in the cell.

[148] In one implementation, the second wake up signal may include a second synchronization signal and/or a second data signal, wherein the second synchronization signal and the second data signal are respectively configured at the base station (or may be called being separately configured). The second synchronization signal may be used for synchronization of all users in the cell. The second data signal may include information of a specific UE or a specific UE group, and the second data signal may wake up the primary communication receiver of the specific UE or UE group to receive data or signals.

[149] In the following description, for convenience of description, the first synchronization signal and the first data signal are called low power synchronization signal-1 (LP-SS-1) and low power wake up data signal-1 (WUS-data-1) respectively, and the second synchronization signal and the second data signal are called low power synchronization signal-2 (LP-SS-2) and low power wake up data signal-2 (WUS-data-2) respectively.

[150] Further, in the following description, for the convenience of understanding, the first wake up signal is exemplarily called "common LPWUS" and the second wake up signal is exemplarily described as "separately configured low power synchronization signal-2 (LP-SS-2) and low power wake up data signal-2 (WUS-data-2)" or "low power synchronization signal-2 (LP-SS-2) and low power wake up data signal-2 (WUS-data-2)".

[151] According to an embodiment of the disclosure, the LPWUS may be a common

LPWUS, or it may be composed of two signals, namely, a low power synchronization signal-2 (LP-SS-2) and a low power wake up data signal-2 (WUS-data-2), which are separately configured.

[152] The common LPWUS may be a low power synchronization signal-1 (LP-SS-1), or it may include two parts, commonly configured LP-SS-1 and low power wake up data signal-1 (WUS-data-1). For example, transmitting the corresponding WUS-data-1 after LP-SS-1 may be used to wake up all users in a cell, and users may obtain first information for all users in the cell through the common LPWUS. The first information may include at least one of the followings:

[153] o system information modification SystemInfoModification;

[154] o earthquake and tsunami warning system and commercial mobile alarm service indication etwsAndCmasIndication;

[155] o stop paging monitoring indication information;

[156] o a physical cell identification (ID);

[157] o a beam index;

[158] o a tracking area/radio access network (RAN) area ID;

[159] o a system information block (SIB) message;

[160] o a main information block (MIB) message;

[161] The indication method of the first information may include one or more of the followings:

[162] o the first information is implied by a physical signal sequence used by LP-SS-1;

[163] o a corresponding field is configured in WUS-data-1, and the UE obtains the corresponding first information by receiving WUS-data-1. For example, the corresponding first information may be included in WUS-data-1, or the indication information for indicating the corresponding first information may be included in WUS-data-1.

[164] The configuration method of the common LPWUS cycle may include one or a combination of the followings:

[165] o the cycle of the common LPWUS may be configured separately. For example, the base station may select and indicate a cycle from preconfigured cycles of the common LPWUS, and the preconfigured cycles of the common LPWUS may include but is not limited to at least one of the followings: 5ms, 10ms, 20ms, 40ms, 80ms, 160ms, 320ms, 640ms and 1280ms. The cycle of the common LPWUS may be indicated by system information, such as SIB;

[166] o the cycle of the common LPWUS is configured according to a modification cycle of the first information, for example, is determined by the modification cycle of a Broadcast control channel (BCCH) adding an offset. Optionally, the cycle of the common LPWUS may be consistent with the modification cycle of the first information, for example, may equal to the modification cycle of the Broadcast control

channel (BCCH). The offset may be a predefined parameter value or a parameter value (pre)configured by the base station.

[167] o the cycle of the common LPWUS is configured according to the cycle of the paging occasion PO or the DRX cycle, for example, is determined by the cycle of the paging occasion PO or the DRX cycle adding an offset. Optionally, the cycle of the common LPWUS may be consistent with the cycle of the paging occasion PO or the DRX cycle, that is, may equal to the cycle of the paging occasion PO or the DRX cycle. The offset may be a predefined parameter value or a parameter value (pre)configured by the base station.

[168] o the cycle of the common LPWUS is configured by a core network.

[169] The method for the UE to monitor the common LPWUS may include one or a combination of the followings:

[170] o The UE may monitor one common LPWUS per common LPWUS cycle;

[171] o the UE may only monitor the common LPWUS transmitted within a predefined or preconfigured time unit before a WUS-data-1 monitoring occasion to receive the first information. The WUS-data-1 monitoring occasion may be configured according to the cycle of the paging occasion PO or the DRX cycle, that is, is determined by the cycle of the paging occasion PO or the DRX cycle adding an offset. Optionally, the cycle of the WUS-data-1 monitoring occasion may be consistent with the cycle of the paging occasion PO or the DRX cycle, that is, may equal to the cycle of the paging occasion PO or the DRX cycle. The offset may be a predefined parameter value or a parameter value (pre)configured by the base station;

[172] In another embodiment, the LPWUS may be composed of two separately configured signals, namely, a low power synchronization signal (LP-SS-2) and a low power wake up data signal (WUS-data-2), wherein the LP-SS-2 may be a cell-specific low power synchronization signal, that is, all users in the cell need to receive the LP-SS-2 to perform downlink synchronization process. Under the condition of keeping the UE synchronized with the network, after the low power wake up data signal is received by the UE, the UE performs corresponding operations, such as waking up the primary communication receiver of the UE to receive data or signals, or transmitting data or signals, or directly establishing RRC connection. Optionally, the UE may receive LP-SS-2 for downlink synchronization and/or RRM measurement, and not receive the synchronization signal and physical broadcast channel (PBCH) block (SSB).

[173] In order to ensure that the LPWUS may be received and decoded correctly, the UE needs to receive LP-SS-2 periodically to ensure clock synchronization of the transmitter and the receiver. The LP-SS-2 may be a primary synchronization signal and/or a secondary synchronization signal, or a non-cell defined SSB (NCD-SSB) or a simplified SSB (Light SSB). Optionally, the LP-SS-2 may also be composed of a

(pre)defined physical signal sequence or one of a plurality of (pre)defined physical signal sequences, and the network side (e.g., the base station) may select a sequence from the plurality of (pre)defined physical signal sequences and configure it as a signal sequence of LP-SS-2, for example, the signal sequence may be indicated by system information, such as indicated by SIB message. The generated sequence of the LP-SS-2 may be one or more new M-sequences. In one implementation, the first information may be contained by the physical signal sequence used by the LP-SS-2. Optionally, the LP-SS-2 may have the same sequence generation method as the primary synchronization signal and/or the secondary synchronization signal. The LP-SS-2 may further reduce power consumption of the UE by amplitude shift keying (ASK) modulation and/or frequency shift keying (FSK) modulation. At this time, the sequence used for modulation may be preconfigured.

[174] The configuration method of the LP-SS-2 cycle may include one or more of the followings:

[175] o the cycle of the LP-SS-2 may be configured separately, that is, the base station may select and indicate a cycle from preconfigured cycles of the LP-SS-2, and the preconfigured cycles of LP-SS-2 may include but not be limited to at least one of the followings: 1.25ms, 2.5ms, 5ms, 10ms, 20ms, 40ms, 80ms and 160ms. Wherein, in order to reduce power consumption when the UE performs downlink synchronization, the LP-SS-2 may be configured with shorter cycles, such as 1.25ms, 2.5ms and 5ms, at this time, the UE may complete the downlink synchronization process in shorter time. The cycle of the LP-SS-2 may be indicated by system information, such as SIB;

[176] o the cycle of the LP-SS-2 is configured according to the cycle of SSB, for example, is determined by the cycle of SSB adding an offset. Optionally, the cycle of the LP-SS-2 may be the same as the cycle of SSB, that is, may equal to the cycle of SSB. The offset may be a predefined parameter value or a parameter value (pre)configured by the base station.

[177] o the cycle of the LP-SS-2 is configured according to the cycle of the paging occasion PO or the DRX cycle, for example, is determined by the cycle of the paging occasion PO or the DRX cycle adding an offset. Optionally, the cycle of the LP-SS-2 may be consistent with the cycle of the paging occasion PO or the DRX cycle, that is, may equal to the cycle of the paging occasion PO or the DRX cycle. The offset may be a predefined parameter value or a parameter value (pre)configured by the base station.

[178] o the cycle of the LP-SS-2 is configured by the core network.

[179] Optionally, the cycle of the common LPWUS is greater than or equal to the cycles of the LP-SS-2 and the WUS-data-2.

[180] The UE may only monitor the LP-SS-2 transmitted in a predefined or preconfigured time unit before the WUS-data-2 monitoring occasion, and complete the downlink syn-

chronization process to reduce power loss caused by the UE's continuous monitoring of the synchronization signal. Wherein, the cycle of the WUS-data-2 monitoring occasion may be determined by the cycle of the paging occasion PO or the DRX cycle adding an offset, and optionally, the cycle of the WUS-data-2 monitoring occasion may be consistent with the cycle of the paging occasion PO or the DRX cycle, that is, may equal to the cycle of the paging occasion PO or the DRX cycle. The offset may be a predefined parameter value or a parameter value (pre)configured by the base station.

[181] If the LP-SS-2 is not received for more than D time units, the PCR of the UE is waked up after the D time units, and the behavior of the UE may include one or a combination of the followings:

[182] o the UE may re-receive SSB considering the higher synchronization accuracy of SSB;

[183] o the UE receives paging to avoid missing paging information;

[184] The D time units may be a parameter value reported by the user equipment UE according to its own processing capacity and/or a parameter value configured by the base station and received by the UE and/or a preconfigured parameter value and/or a predefined parameter value. Wherein D is a real number greater than 0.

[185] The WUS-data-2 may transmit all or part of the paging message of the UE. In one implementation, all or part of the paging message that may be transmitted in the WUS-data-2 may include but not limited to at least one of the followings:

[186] o list of the paged UEs pagingRecordList, with value of the sequence of PagingRecord, PagingRecord contains ue-Identity and/or accessType. ue-Identity may uniquely specify a UE, including S-TMSI and/or I-RNTI, wherein S-TMSI is a temporary UE identification number and I-RNTI is used for identification of the identity information of a terminal device and identification of the identity information of a serving base station. Optionally, only the UE in RRC_INACTIVE and/or RRC_IDLE state reads the information in pagingRecordList;

[187] o late non-critical extension lateNonCriticalExtension;

[188] o non-critical extension nonCriticalExtension, containing pagingRecordList-v1700 and/or pagingGroupList-r17 field. Wherein the value of pagingRecordList-v1700 is the sequence of PagingRecord-v1700, and the value of pagingGroupList-r17 is the sequence of temporary group identifier TMGI-r17;

[189] o system information modification systemInfoModification, indicating the update of broadcast channel messages except for SIB6, SIB7 and SIB8 if set to 1;

[190] o earthquake and tsunami warning system and commercial mobile alarm service indication etwsAndCmasIndication, indicating earthquake and tsunami warning system (ETWS) primary notification and/or ETWS secondary notification and/or commercial mobile alarm service (CMAS) notification if set to 1;

[191] o stop paging monitoring stopPagingMonitoring indication, indicating the UE to stop monitoring the physical downlink control channel (PDCCH) transmission occasion paged in the PO if set to 1;

[192] The indication field of the WUS-data-2 may contain a LPWUS-related control signal, for example, information about the LPWUS in the next cycle may be included in the WUS-data-2. For example, the UE may determine the LPWUS-related control signal in the next cycle through the WUS-data-2 of the previous cycle. In one implementation, if the WUS-data-2 contains multiple indication fields, the UE may determine the field size of the LPWUS in the next cycle through the WUS-data-2 of the previous cycle. Optionally, the UE may determine whether the system information modification SystemInfoModification indication field exists in the WUS-data-2 in the next cycle through the WUS-data-2 of the previous cycle. Optionally, 1 bit may be used in the WUS-data-2 to indicate whether the system information modification indication field exists in the WUS-data-2 in the next cycle. If it is 0, the system information modification indication field does not exist in the WUS-data-2 in the next cycle. If it is 1, the system information modification indication field exists in the WUS-data-2 in the next cycle. Such operation may reduce power loss caused by the UE's reception of repetitive fields of the WUS-data-2.

[193] The method for the UE to determine a frequency domain resource location of common LPWUS and/or the low power synchronization signal-2 (LP-SS-2) and/or the low power wake up data signal-2 (WUS-data-2) in the LPWUS may include one or a combination of the followings:

[194] o the frequency domain resource location of the LPWUS may be calculated from a Point A calculated from the SSB subcarrier offset carried by main information block and the offset from the Point A OffsetToPointA and a predefined or preconfigured offset, the granularity of the predefined or preconfigured offset is a subcarrier or a physical resource block (PRB);

[195] o optionally, the UE may obtain a frequency domain starting location of the common LPWUS and/or the low power synchronization signal-2 (LP-SS-2) and/or the low power wake up data signal-2 (WUS-data-2) in the LPWUS through a frequency domain location of the SSB, and frequency domain starting location of the common LPWUS and/or the low power synchronization signal-2 (LP-SS-2) and/or the low power wake up data signal-2 (WUS-data-2) in the LPWUS may be determined by the frequency domain location of the SSB adding an offset. The frequency domain location of the SSB may be the central frequency domain location of the SSB or the initial subcarrier of the SSB. The offset may be a predefined parameter value or a parameter value (pre)configured by the base station.

[196] o the frequency domain resource location (for example, a unique fixed frequency

domain resource location) is determined through the frequency band where the PO is located;

[197] o the frequency domain resource location may be determined according to the frequency location of the search space for monitoring the associated PO. Optionally, the same starting PRB as that of the PO search space is used as the frequency domain starting location of the common LPWUS and/or the low power synchronization signal-2 (LP-SS-2) and/or the low power wake up data signal-2 (WUS-data-2) in the LPWUS. Optionally, the same starting PRB as that of the PO search space plus an offset are used as the frequency domain starting location of the common LPWUS and/or the low power synchronization signal-2 (LP-SS-2) and/or the low power wake up data signal-2 (WUS-data-2) in the LPWUS. The offset may be a predefined parameter value or a parameter value (pre)configured by the base station.

[198] o the frequency domain resource location may correspond to a global synchronization channel number one-by-one, that is, there is a unique frequency domain location within each global synchronization channel, and the UE may determine the frequency domain location of the LP-SS-2 by blind detection.

[199] The configuration method of the subcarrier space of the common LPWUS and/or the low power synchronization signal-2 (LP-SS-2) and/or the low power wake up data signal-2 (WUS-data-2) in the LPWUS may include one or more of the followings:

[200] o the subcarrier space of the common LPWUS and/or the low power synchronization signal-2 (LP-SS-2) and/or the low power wake up data signal-2 (WUS-data-2) in the LPWUS is configured separately, and the subcarrier space of the currently configured LPWUS is indicated by the base station through system information, such as SIB;

[201] o In some specific scenarios, such as Enhanced Mobile Broadband (EMBB) and/or Extended Reality (XR) scenarios, in order to satisfy the requirement of low delay, in frequency range 1 (FR1), the subcarrier space of the common LPWUS and/or the low power synchronization signal-2 (LP-SS-2) and/or the low power wake up data signal-2 (WUS-data-2) in the LPWUS is fixed to G1, and in frequency range 2 (FR2), the subcarrier space of the common LPWUS and/or the low power synchronization signal-2 (LP-SS-2) and/or the low power wake up data signal-2 (WUS-data-2) in the LPWUS is fixed to G2, where G1 and G2 are predefined parameter values or parameter values (pre)configured by the base station, and G1 and G2 are greater than or equal to a first threshold (for example, 244), and optionally, G1 and G2 may be 480kHz, 960 kHz;

[202] o considering that the LPWUS receiver independent from the primary communication receiver may not be able to remove the cyclic prefix (CP) added between OFDM symbols, the existence of CP will cause reception error of the LPWUS in time domain. In order to reduce the influence of the CP on reception of the LPWUS, in frequency range 1 (FR1), the subcarrier space of the common LPWUS and/or the low

power synchronization signal-2 (LP-SS-2) and/or the low power wake up data signal-2 (WUS-data-2) in the LPWUS is fixed to G3, and in frequency range 2 (FR2), the subcarrier space of the common LPWUS and/or the low power synchronization signal-2 (LP-SS-2) and/or the low power wake up data signal-2 (WUS-data-2) in the LPWUS is fixed to G4, where G3 and G4 are predefined parameter values or parameter values (pre)configured by the base station, and G3 and G4 are less than a second threshold (for example, 1.875 kHz), .and optionally, G3 and G4 may be 7.5kHz, 3.75kHz, 1.875kHz, 0.9375kHz, 0.46875kHz,

[203] o the subcarrier space of the common LPWUS and/or the low power synchronization signal-2 (LP-SS-2) and/or the low power wake up data signal-2 (WUS-data-2) in the LPWUS is configured according to the subcarrier space of initial downlink bandwidth part (BWP) or SSB or CORESET0, for example, is consistent with the subcarrier space of the initial downlink bandwidth part (BWP) or SSB or CORESET0, that is, may equal to the subcarrier space of the initial downlink Bandwidth part (BWP) or SSB or CORESET0;

[204] When the UE may support a variety of LPWUS reception methods, for example, when the UE has the capacity to receive and demodulate amplitude shift keying and/or frequency shift keying LPWUS signals, the UE may report all supported LPWUS modulation modes to the base station, and the base station indicates which LPWUS modulation mode to use, and the adopted LPWUS modulation mode may be indicated by system information, such as SIB.

[205] When the LPWUS is transmitted using M-bit frequency shift keying FSK, the larger the interval between M frequencies, that is, the larger the bandwidth, the better the de-modulation performance. The carrier frequency locations of M-bit FSK may be fixed or configured. When bandwidth B of the LPWUS is configured, the carrier frequency configuration method of M-bit FSK may include one or combination of the followings:

[206] o the carrier frequencies may be determined according to the center carrier frequency of the current frequency band, and optionally, may be determined by the center carrier frequency of the current frequency band adding an offset. The offset may be a predefined parameter value or a parameter value (pre)configured by the base station.

[207] o the carrier frequency may be determined according to the bandwidth of the LPWUS and a first frequency domain location. For example, within the bandwidth B of the LPWUS, starting from the Lth frequency domain unit, with the B-L frequency domain units as the cut-off frequency location, in frequency range from L to B-L, the corresponding carrier frequency is selected every (B-2*L)/(M-1) frequency band for frequency shift keying modulation of the LPWUS;

[208] o when the LPWUS is transmitted using M-bit frequency shift keying FSK, in order to improve demodulation performance of the receiver and reduce the influence caused

by the frequency offset, the interval between two adjacent carrier frequencies should not be less than a threshold value T;

[209] o the bandwidth B, M bits, L frequency domain units and the threshold value T may be parameter values reported by the user equipment UE according to its own processing capability and/or parameter values configured by the base station and received by the UE and/or a preconfigured parameter value. Where B, M, L and T are real numbers greater than 0.

[210] FIG. 4 illustrates an example flowchart of a method 400 performed by a UE according to an embodiment of the disclosure.

[211] As illustrated in FIG. 4, the method 400 includes the following steps:

[212] Step 401: the UE monitors a wake up signal; and

[213] Step 402: wake up the UE after the wake up signal is monitored by the UE.

[214] According to an embodiment of the disclosure, the wake up signal includes a first wake up signal and/or a second wake up signal, wherein the first wake up signal includes a first synchronization signal for a cell or a first synchronization signal for the cell and a first data signal, and the second wake up signal includes a second synchronization signal for the cell and/or a second data signal for a UE group.

[215] FIG. 5 illustrates an example flowchart of a method 500 performed by a base station according to an embodiment of the disclosure.

[216] As illustrated in FIG. 5, the method 500 includes the following steps:

[217] Step 501: the base station transmits a wake up signal to a UE, and the wake up signal is used to wake up the UE; and

[218] Step 502: the base station transmits a signal and/or a channel to the UE and/or receives a signal and/or a channel from the UE.

[219] According to an embodiment of the disclosure, the wake up signal includes a first wake up signal and/or a second wake up signal, wherein the first wake up signal includes a first synchronization signal for a cell or a first synchronization signal for the cell and a first data signal, and the second wake up signal includes a second synchronization signal for the cell and/or a second data signal for a UE group.

[220] FIG. 6 illustrates an example hardware block diagram of a UE 600 according to an embodiment of the disclosure. Referring to FIG. 6, the UE 600 may include a transceiver 601 and a processor 602, wherein the processor may also be called a controller and the like.

[221] The transceiver 601 may be configured to transmit and/or receive a signal.

[222] The processor 602 may be an application specific integrated circuit or at least one processor. The processor 602 may be configured to control the overall operation of the UE and control the UE to implement the method proposed in the embodiments of the disclosure.

[223] FIG. 7 illustrates an example hardware block diagram of a base station 700 according to an embodiment of the disclosure.

[224] Referring to FIG. 7, the base station 700 may include a transceiver 701 and a processor 702, wherein the processor may also be a controller or the like.

[225] The transceiver 701 may be configured to transmit and/or receive a signal.

[226] The processor 702 may be an application specific integrated circuit or at least one processor. The processor 702 may be configured to control the overall operation of the base station and control the base station to implement the method proposed in the embodiments of the disclosure.

[227] Those skilled in the art will understand that the illustrative embodiments described above are described herein and are not intended to be limiting. It should be understood that any two or more of the embodiments disclosed herein may be combined in any combination. In addition, other embodiments may be utilized and other changes may be made without departing from the spirit and scope of the subject matter presented herein. It will be easily understood that aspects of the invention of the disclosure, as generally described herein and illustrated in the accompanying drawings, may be arranged, substituted, combined, separated and designed in various different configurations, all of which are contemplated herein.

[228] Those skilled in the art will appreciate that the various illustrative logical blocks, modules, circuits, and steps described herein may be implemented as hardware, software, or a combination of both. In order to clearly illustrate this interchangeability between hardware and software, various illustrative components, blocks, modules, circuits, and steps are generally described in the form of their function sets. Whether such a function set is implemented as hardware or software depends on the specific application and the design constraints imposed on the overall system. Skilled people may implement the described function set in different ways for each specific application, but such design decisions should not be interpreted as causing a departure from the scope of this application.

[229] The illustrative logical blocks, modules, and circuits described in this application may be implemented in a general-purpose processor, a Digital Signal Processor (DSP), an application specific integrated circuit (ASIC), Field Programmable Gate Array (FPGA) or other programmable logic devices, a discrete gate or transistor logic, a discrete hardware component, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, such as a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors cooperating with a DSP core, or any

other such configuration.

[230] The steps of a method or algorithm described herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of both. A software module may reside in a RAM memory, a flash memory, a ROM memory, a EPROM memory, a EEPROM memory, a register, a hard disk, a removable disk, or any other form of storage media known in the art. An exemplary storage medium is coupled to a processor to enable the processor to read and write information from/to the storage medium. In the alternative, the storage medium may be integrated into the processor. The processor and storage medium may reside in an ASIC. The ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as separate components in the user terminal.

[231] In one or more exemplary designs, the functions may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, each function may be stored on or transferred by computer-readable medium as one or more instructions or codes. Computer-readable media includes both computer storage media and communication media, and the latter includes any media that facilitates the transfer of computer programs from one place to another. The storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[232] The above is only an exemplary embodiment of the present invention, and is not used to limit the protection scope of the present invention, which is defined by the appended claims.

Claims

[Claim 1] A method performed by a user equipment (UE) in a communication system, comprising:
monitoring a wake up signal;
waking up the UE after the wake up signal is monitored,
wherein the wake up signal comprises a first wake up signal and/or a second wake up signal,
the first wake up signal comprises a first synchronization signal for a cell, or comprises the first synchronization signal for the cell and a first data signal,
the second wake up signal comprises a second synchronization signal for the cell and/or a second data signal for a UE group.

[Claim 2] The method of claim 1, wherein the first synchronization signal and the first data signal are in the same piece of wake up signal; or
the UE monitors the first data signal on a first time unit configured by a base station after the first synchronization signal is monitored.

[Claim 3] The method of claim 1, wherein the monitoring of the wake up signal comprises:
monitoring the second data signal according to a third cycle configured by a base station.

[Claim 4] The method of claim 1, wherein
the first synchronization signal is further for indicating first information, and/or
the second synchronization signal is further for indicating the first information, and/or
the first data signal is further for indicating the first information, and/or
the first data signal comprises the first information;
wherein the first information comprises at least one of the followings:
system information modification SystemInfoModification;
earthquake and tsunami warning system and commercial mobile alarm service indication etwsAndCmasIndication;
stop paging monitoring indication information;
a physical cell identification ID;
a beam index;
a tracking area/radio access network RAN area ID;
a system information block SIB message;
a main information block MIB message.

[Claim 5] The method of claim 4, wherein a cycle for the first wake up signal is determined by at least one of the followings:
determined based on at least one first cycle configured by a base station;
determined based on a modification cycle of the first information;
determined based on a cycle of a paging occasion PO or a dis-continuous reception DRX cycle; configured by a core network.
wherein the at least one first cycle comprises at least one of 5ms, 10ms, 20ms, 40ms, 80ms, 160ms, 320ms, 640ms and 1280ms, and
wherein the cycle for the first wake up signal is one of the at least one first cycle indicated by the SIB.

[Claim 6] The method of claim 1, wherein a cycle for the second synchronization signal is determined by at least one of the followings:
determined based on at least one second cycle configured by a base station;
determined based on a cycle of a synchronization signal and physical broadcast channel PBCH block SSB;
determined based on a cycle of a PO or a DRX cycle;
configured by a core network,
, wherein the at least one second cycle comprises at least one of 1.25ms, 2.5ms, 5ms, 10ms, 20ms, 40ms, 80ms, and 160ms, and
wherein the cycle for the second synchronization signal is one of the at least one second cycle indicated by an SIB.

[Claim 7] The method of claim 1, further comprising:
waking up the UE to receive an SSB and/or receive a paging message if the UE does not receive the second synchronization signal within a first time period,
wherein a number of time units corresponding to the first time period is configured by a base station or reported to the base station by the UE.

[Claim 8] The method of claim 1, wherein the second data signal comprises part or all of a paging message.
wherein the second data signal comprises at least one of the followings:
list of the paged UEs pagingRecordList;
late non-critical extension lateNonCriticalExtension;
non-critical extension nonCriticalExtension;
system information modification systemInfoModification;
earthquake and tsunami warning system and commercial mobile alarm service indication etwsAndCmasIndication;

stop paging monitoring stopPagingMonitoring indication; and information about the wake up signal in the next cycle,
wherein the information about the wake up signal in the next cycle comprises a field size of the wake up signal in the next cycle and/or information indicating whether one or more fields exist in the next cycle.

[Claim 9] The method of claim 1, wherein a cycle for the first wake up signal is greater than or equal to a cycle for the second wake up signal.

[Claim 10] The method of claim 1, wherein a frequency domain resource location of the wake up signal is determined by at least one of the followings:
determined based on a Point A and a first offset, wherein the point A is obtain by an SSB subcarrier offset and an offset from the Point A OffsetToPointA;
a frequency domain starting location of the wake up signal being determined according to a frequency domain location of an SSB;
determined according to a frequency band where a PO is located;
determined according to a frequency location of search space used for PO monitoring;
determined by blind detection in a global synchronization channel.

[Claim 11] The method of claim 1, wherein a subcarrier space of the wake up signal is at least one of the followings:
a subcarrier space indicated by a base station through system information;
a first subcarrier space corresponding to frequency domain range 1;
a second subcarrier space corresponding to frequency range 2;
a third subcarrier space corresponding to frequency domain range 1;
a fourth subcarrier space corresponding to frequency range 2;
a subcarrier space configured according to a subcarrier space of initial downlink bandwidth part BWP or SSB or CORESET0,
wherein the first subcarrier space and the second subcarrier space are both greater than or equal to a first threshold,
wherein the third subcarrier space and the fourth subcarrier space are both smaller than a second threshold.

[Claim 12] The method of claim 1, wherein the wake up signal is modulated based on M-bit frequency shift keying FSK, and carrier frequencies of the M-bit FSK are determined by at least one of the followings:
determined according to a central carrier frequency of a frequency band configured by the UE;
determined according to a first bandwidth and a first starting frequency

domain location of the wake up signal;
wherein an interval between adjacent carrier frequencies in the carrier frequencies of the M-bit FSK is greater than or equal to a first threshold value,
wherein the first bandwidth, M, the first starting frequency domain location and the first threshold value are reported by the UE or configured by a base station.

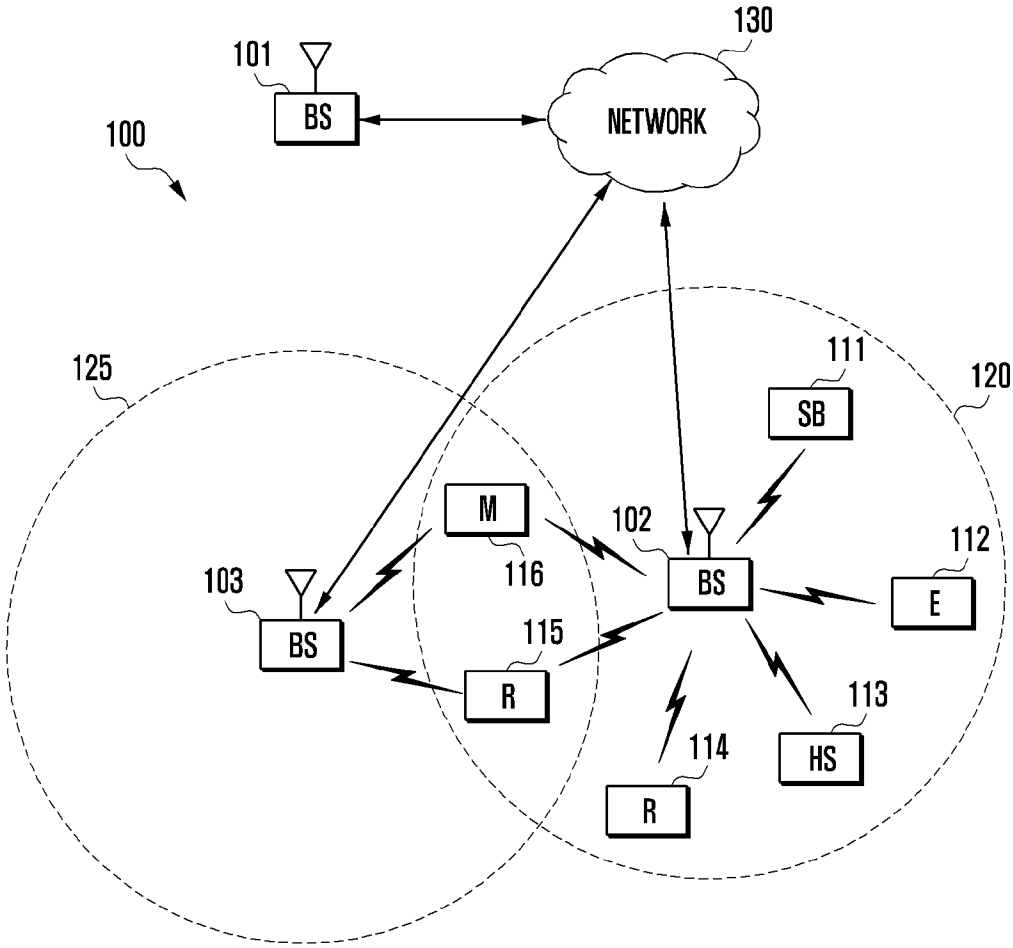
[Claim 13] The method of claim 1, further comprising:
reporting a modulation mode supported by the UE for the wake up signal to a base station; and
receiving a modulation mode for the wake up signal indicated by the base station through an SIB,
the monitoring of the wake up signal comprises monitoring the wake up signal based on the indicated modulation mode.

[Claim 14] A method performed by a base station in a communication system, comprising:
transmitting a wake up signal to a UE, wherein the wake up signal is for waking up the UE;
transmitting a signal and/or channel to the UE and/or receiving a signal and/or channel from the UE,
wherein the wake up signal comprises a first wake up signal and/or a second wake up signal,
the first wake up signal comprises a first synchronization signal for a cell, or comprises the first synchronization signal for the cell and a first data signal,
the second wake up signal comprises a second synchronization signal for the cell and/or a second data signal for a UE group.

[Claim 15] A user equipment (UE) in a communication system, comprising:
a transceiver; and
at least one processor configured to:
monitor a wake up signal;
wake up the UE after the wake up signal is monitored,
wherein the wake up signal comprises a first wake up signal and/or a second wake up signal,
the first wake up signal comprises a first synchronization signal for a cell, or comprises the first synchronization signal for the cell and a first data signal,
the second wake up signal comprises a second synchronization signal

for the cell and/or a second data signal for a UE group.

[Fig. 1]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101
BS
NETWORK
100
125
111
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SB
M
102
112
116
103
BS
BS
E
115
R
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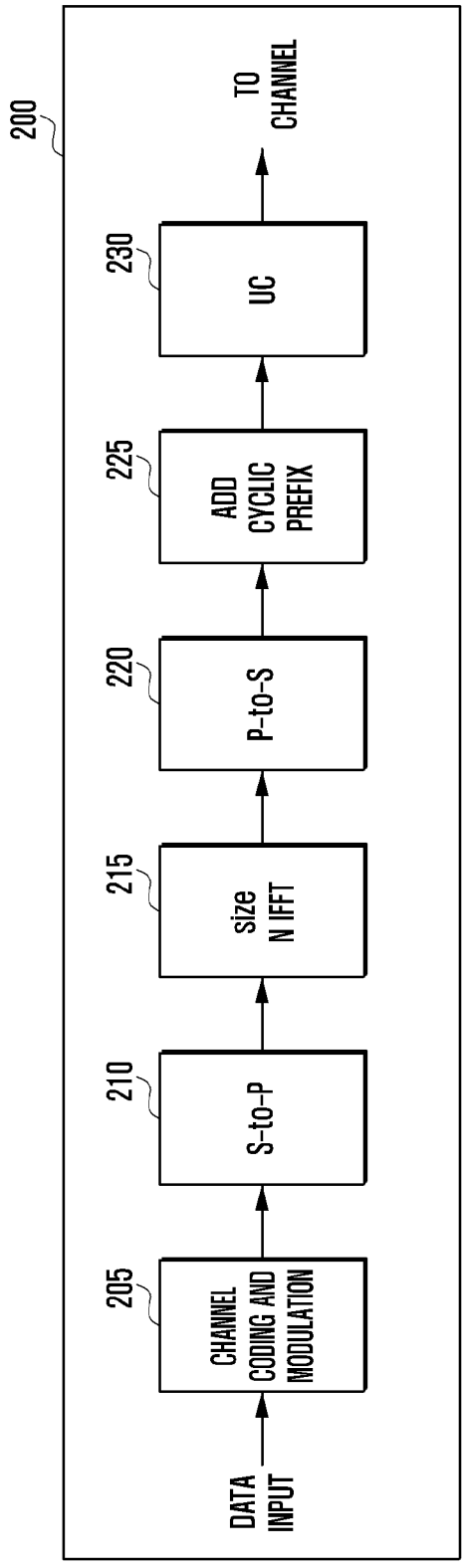
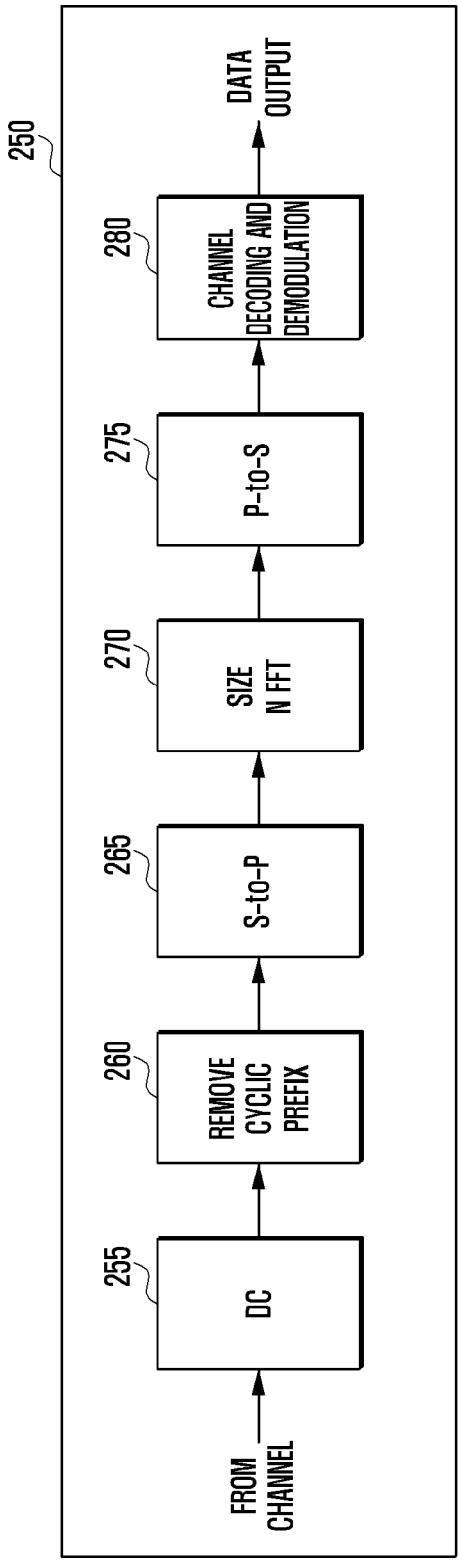
HS
R

[Fig. 2a]


200
DATA INPUT
205
CHANNEL CODING AND MODULATION
210
S-to-P
215
size N IFFT
220
P-to-S
225
ADD CYCLIC PREFIX
230
UC
TO CHANNEL

[Fig. 2b]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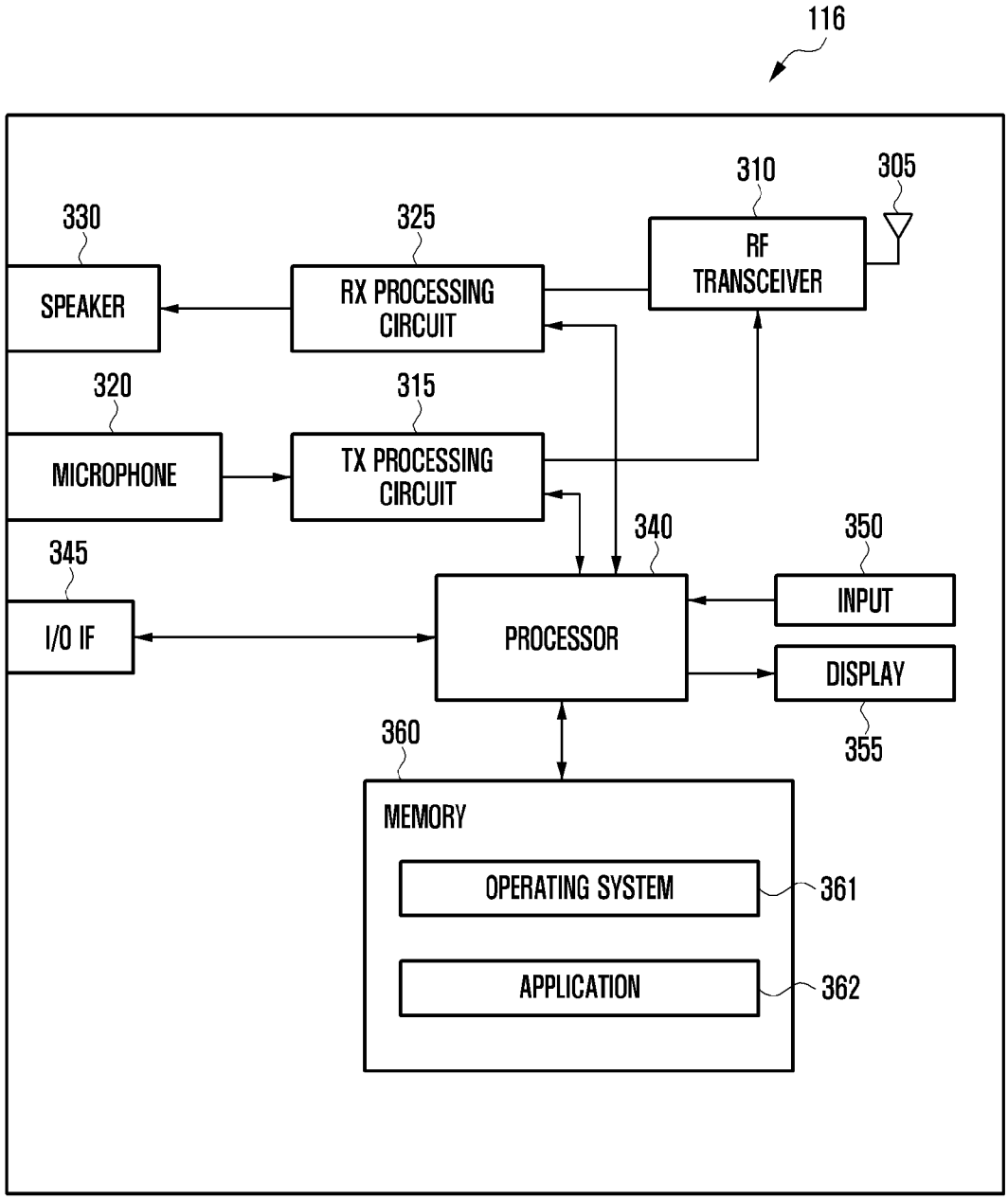
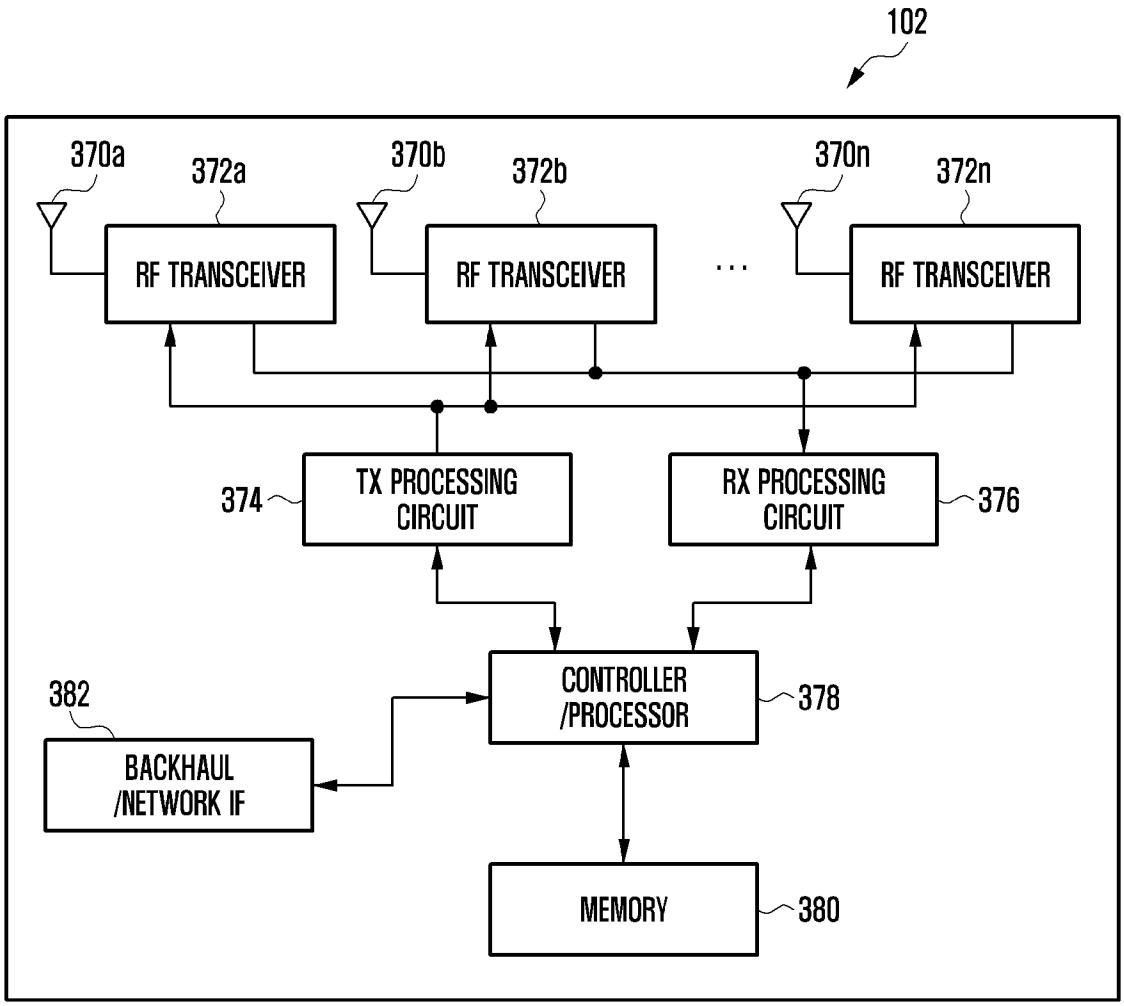
FROM CHANNEL
255
DC
260
REMOVE CYCLIC PREFIX
265
S-to-P
270
SIZE N FFT
275
P-to-S
280
CHANNEL DECODING AND DEMODULATION
DATA OUTPUT

[Fig. 3a]


116
310
305
330
325
RF TRANSCEIVER
SPEAKER
RX PROCESSING CIRCUIT
320
315
MICROPHONE
TX PROCESSING CIRCUIT
340
350
345
INPUT
I/O IF
PROCESSOR
DISPLAY
355
360
MEMORY
OPERATING SYSTEM
361
APPLICATION
362

[Fig. 3b]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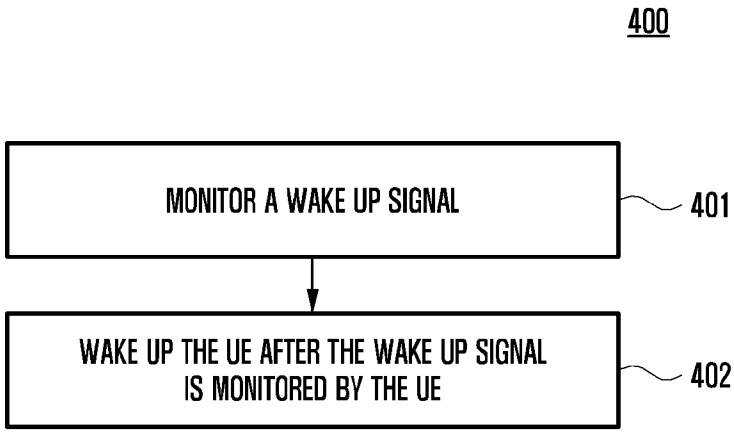
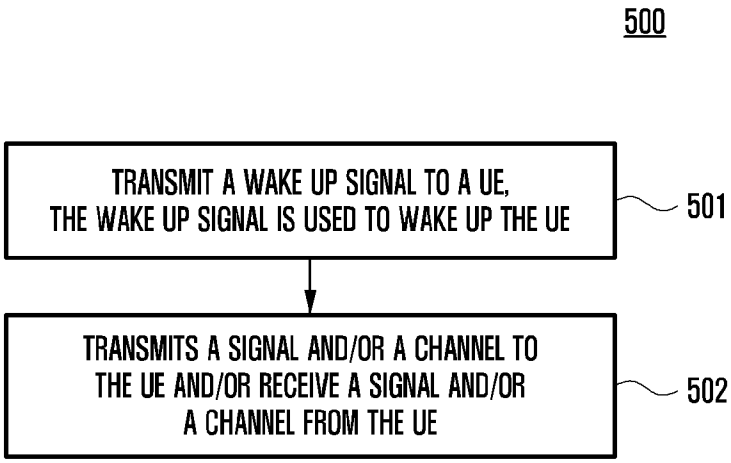
370a
372a
370b
372b
370n
372n
RF TRANSCEIVER
RF TRANSCEIVER
RF TRANSCEIVER
374
TX PROCESSING CIRCUIT
RX PROCESSING CIRCUIT
376
382
CONTROLLER /PROCESSOR
378
BACKHAUL /NETWORK IF
MEMORY
380

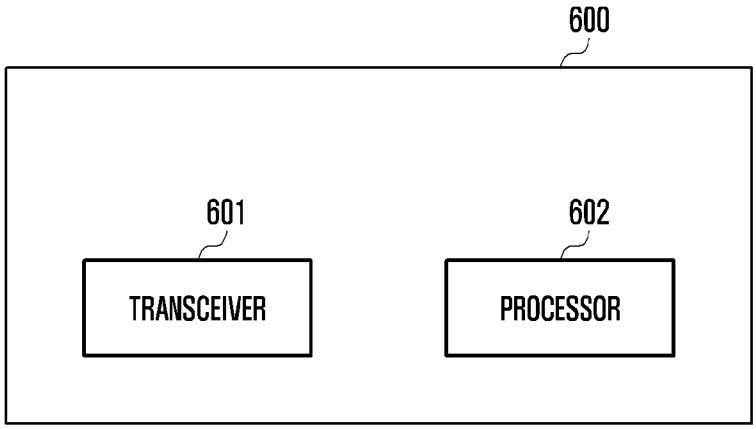
[Fig. 4]


400
MONITOR A WAKE UP SIGNAL
401
WAKE UP THE UE AFTER THE WAKE UP SIGNAL IS MONITORED BY THE UE
402

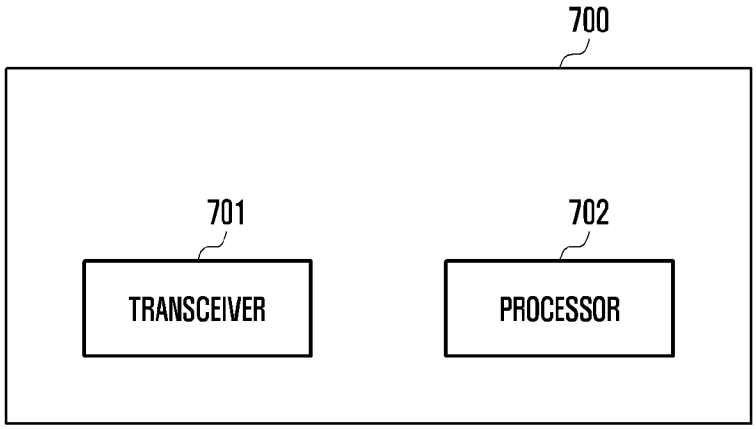
[Fig. 5]



[Fig. 6]



[Fig. 7]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2024/000234

A. CLASSIFICATION OF SUBJECT MATTER

H04W 52/02(2009.01)i; **H04W 48/10**(2009.01)i; **H04W 56/00**(2009.01)i; **H04W 4/90**(2018.01)i; **H04W 68/02**(2009.01)i; **H04W 76/28**(2018.01)i; **H04L 27/10**(2006.01)i

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)

H04W 52/02(2009.01); H04W 76/28(2018.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: wake up signal, synchronization signal, UE group, cell, cycle, paging message, M-bit FSK

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	HUAWEI et al., `Signal design and procedure for LP-WUS`, R1-2210910, 3GPP TSG RAN WG1 Meeting #111, Toulouse, France, 07 November 2022	
X	sections 2.2.2-5	1-2,4,8,10-12,14-15
Y		3,5-7,9,13
	QUALCOMM INCORPORATED, `L1 signal design and procedures for LP-WUR`, R1-2212144, 3GPP TSG RAN1 Meeting #111, Toulouse, 07 November 2022	
Y	sections 3-5	3,5-7,9
	US 2020-0351780 A1 (MEDIATEK INC.) 05 November 2020 (2020-11-05)	
Y	paragraphs [0032], [0059]; and claim 1	13
	NEC, `Discussion on L1 signal design and procedure for LP-WUS`, R1-2212366, 3GPP TSG RAN WG1 #111, Toulouse, France, 07 November 2022	
A	sections 2-3	1-15

☑ Further documents are listed in the continuation of Box C.

☑ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
08 April 2024	**08 April 2024**

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	APPLE INC., `On the L1 signal design and procedures for low power wake-up signal`, R1-2211836, 3GPP TSG RAN WG1 #111, Toulouse, France, 07 November 2022 sections 1-4	1-15

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2024/000234

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
US 2020-0351780 A1	05 November 2020	CN 112189364 A	05 January 2021
		CN 112262596 A	22 January 2021
		CN 112262596 B	19 December 2023
		US 11297574 B2	05 April 2022
		US 2020-0351774 A1	05 November 2020
		WO 2020-224526 A1	12 November 2020
		WO 2020-224533 A1	12 November 2020