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PATTERN FOR SS/PBCH BLOCK

Abstract

Apparatuses and methods for patterns for synchronization signal block (SSB). A method of a user equipment (UE) in a wireless communication system includes receiving a set of higher layer parameters and identifying, based on the set of higher layer parameters, a set of configurations related to synchronization signals and physical broadcast channel (SS/PBCH) blocks. The set of configurations include a time domain interval between two consecutive SS/PBCH blocks in a burst or an indication of a structure of the SS/PBCH blocks in the burst. The method further includes receiving the SS/PBCH blocks, based on the set of configurations.

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Background/Summary

CROSS-REFERENCE TO RELATED AND CLAIM OF PRIORITY [0001] The present application claims priority under 35 U.S.C. § 119(e) to U.S. Provisional Patent Application No. 63/556,178 filed on Feb. 21, 2024, and U.S. Provisional Patent Application No. 63/730,175 filed on Dec. 10, 2024, which are hereby incorporated by reference in their entirety.

TECHNICAL FIELD

[0002] The present disclosure relates generally to wireless communication systems and, more specifically, the present disclosure is related to apparatuses and methods for patterns for a synchronization signal and/or physical broadcast channel (SS/PBCH) block or SSB.

BACKGROUND

[0003] Wireless communication has been one of the most successful innovations in modern history. Recently, the number of subscribers to wireless communication services exceeded five billion and continues to grow quickly. The demand of wireless data traffic is rapidly increasing due to the growing popularity among consumers and businesses of smart phones and other mobile data devices, such as tablets, “note pad” computers, net books, eBook readers, and machine type of devices. In order to meet the high growth in mobile data traffic and support new applications and deployments, improvements in radio interface efficiency and coverage are of paramount importance. To meet the demand for wireless data traffic having increased since deployment of 4G communication systems, and to enable various vertical applications, 5G communication systems have been developed and are currently being deployed.

SUMMARY

[0004] The present disclosure relates to patterns for an SS/PBCH block or SSB.

[0005] In one embodiment, a user equipment (UE) in a wireless communication system is provided. The UE includes a transceiver configured to receive a set of higher layer parameters and a processor operably coupled to the transceiver. The processor is configured to identify, based on the set of higher layer parameters, a set of configurations related to synchronization signals and physical broadcast channel (SS/PBCH) blocks. The set of configurations include a time domain interval between two consecutive SS/PBCH blocks in a burst or an indication of a structure of the SS/PBCH blocks in the burst. The transceiver is further configured to receive the SS/PBCH blocks, based on the set of configurations.

[0006] In another embodiment, a base station (BS) in a wireless communication system is provided. The BS includes a processor configured to determine a set of configurations related to SS/PBCH blocks and determine a set of higher layer parameters including the set of configurations. The set of configurations include a time domain interval between two consecutive SS/PBCH blocks in a burst or an indication of a structure of the SS/PBCH blocks in the burst. The BS further includes a transceiver operably coupled to the processor. The transceiver is configured to transmit the set of higher layer parameters and transmit the SS/PBCH blocks based on the set of configurations.

[0007] In yet another embodiment, a method of a UE in a wireless communication system is provided. The method includes receiving a set of higher layer parameters and identifying, based on the set of higher layer parameters, a set of configurations related to SS/PBCH blocks. The set of configurations include a time domain interval between two consecutive SS/PBCH blocks in a burst or an indication of a structure of the SS/PBCH blocks in the burst. The method further includes receiving the SS/PBCH blocks, based on the set of configurations.

[0008] Before undertaking the DETAILED DESCRIPTION below, it may be advantageous to set forth definitions of certain words and phrases used throughout this patent document. The term “couple” and its derivatives refer to any direct or indirect communication between two or more

elements, whether or not those elements are in physical contact with one another. The terms "transmit," "receive," and "communicate," as well as derivatives thereof, encompass both direct and indirect communication. The terms "include" and "comprise," as well as derivatives thereof, mean inclusion without limitation. The term "or" is inclusive, meaning and/or. The phrase "associated with," as well as derivatives thereof, means to include, be included within, interconnect with, contain, be contained within, connect to or with, couple to or with, be communicable with, cooperate with, interleave, juxtapose, be proximate to, be bound to or with, have, have a property of, have a relationship to or with, or the like. The term "controller" means any device, system, or part thereof that controls at least one operation. Such a controller may be implemented in hardware or a combination of hardware and software and/or firmware. The functionality associated with any particular controller may be centralized or distributed, whether locally or remotely. The phrase "at least one of," when used with a list of items, means that different combinations of one or more of the listed items may be used, and only one item in the list may be needed. For example, "at least one of: A, B, and C" includes any of the following combinations: A, B, C, A and B, A and C, B and C, and A and B and C.
[0009] Moreover, various functions described below can be implemented or supported by one or more computer programs, each of which is formed from computer readable program code and embodied in a computer readable medium. The terms "application" and "program" refer to one or more computer programs, software components, sets of instructions, procedures, functions, objects, classes, instances, related data, or a portion thereof adapted for implementation in a suitable computer readable program code. The phrase "computer readable program code" includes any type of computer code, including source code, object code, and executable code. The phrase "computer readable medium" includes any type of medium capable of being accessed by a computer, such as read only memory (ROM), random access memory (RAM), a hard disk drive, a compact disc (CD), a digital video disc (DVD), or any other type of memory. A "non-transitory" computer readable medium excludes wired, wireless, optical, or other communication links that transport transitory electrical or other signals. A non-transitory computer readable medium includes media where data can be permanently stored and media where data can be stored and later overwritten, such as a rewritable optical disc or an erasable memory device.
[0010] Definitions for other certain words and phrases are provided throughout this patent document. Those of ordinary skill in the art should understand that in many if not most instances, such definitions apply to prior as well as future uses of such defined words and phrases.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0011] For a more complete understanding of the present disclosure and its advantages, reference is now made to the following description taken in conjunction with the accompanying drawings, in which like reference numerals represent like parts:
[0012] FIG. **1** illustrates an example wireless network according to embodiments of the present disclosure;
[0013] FIG. **2** illustrates an example gNodeB (gNB) according to embodiments of the present disclosure;
[0014] FIG. **3** illustrates an example UE according to embodiments of the present disclosure;
[0015] FIGS. **4**A and **4**B illustrate an example of a wireless transmit and receive paths according to embodiments of the present disclosure;
[0016] FIG. **5** illustrates a diagram of example on-demand SSB patterns according to embodiments of the present disclosure;
[0017] FIG. **6** illustrates a diagram of example on-demand SSB patterns according to embodiments

of the present disclosure;
[0018] FIG. **7** illustrates a diagram of example on-demand SSB patterns according to embodiments of the present disclosure;
[0019] FIG. **8** illustrates a flowchart of an example UE procedure for receiving an on-demand SSB according to embodiments of the present disclosure; and
[0020] FIG. **9** illustrates a flowchart of an example method performed by a UE in a wireless communication system according to embodiments of the present disclosure.

DETAILED DESCRIPTION

[0021] FIGS. **1-8**, discussed below, and the various, non-limiting embodiments used to describe the principles of the present disclosure in this patent document are by way of illustration only and should not be construed in any way to limit the scope of the disclosure. Those skilled in the art will understand that the principles of the present disclosure may be implemented in any suitably arranged system or device.
[0022] To meet the demand for wireless data traffic having increased since deployment of 4G communication systems, and to enable various vertical applications, 5G/NR communication systems have been developed and are currently being deployed. The 5G/NR communication system is implemented in higher frequency (mmWave) bands, e.g., 28 GHz or 60 GHz bands, so as to accomplish higher data rates or in lower frequency bands, such as 6 GHz, to enable robust coverage and mobility support. To decrease propagation loss of the radio waves and increase the transmission distance, the beamforming, massive multiple-input multiple-output (MIMO), full dimensional MIMO (FD-MIMO), array antenna, an analog beam forming, large scale antenna techniques are discussed in 5G/NR communication systems.
[0023] In addition, in 5G/NR communication systems, development for system network improvement is under way based on advanced small cells, cloud radio access networks (RANs), ultra-dense networks, device-to-device (D2D) communication, wireless backhaul, moving network, cooperative communication, coordinated multi-points (CoMP), reception-end interference cancelation and the like.
[0024] The discussion of 5G systems and frequency bands associated therewith is for reference as certain embodiments of the present disclosure may be implemented in 5G systems. However, the present disclosure is not limited to 5G systems, or the frequency bands associated therewith, and embodiments of the present disclosure may be utilized in connection with any frequency band. For example, aspects of the present disclosure may also be applied to deployment of 5G communication systems, 6G, or even later releases which may use terahertz (THz) bands.
[0025] The following documents and standards descriptions are hereby incorporated by reference into the present disclosure as if fully set forth herein: [1] 3GPP TS 38.211 v17.1.0, “NR; Physical channels and modulation;” [2] 3GPP TS 38.212 v17.1.0, “NR; Multiplexing and channel coding;” [3] 3GPP TS 38.213 v17.1.0, “NR; Physical layer procedures for control;” [4] 3GPP TS 38.214 v17.1.0, “NR; Physical layer procedures for data;” and [5] 3GPP TS 38.331 v17.1.0, “NR; Radio Resource Control (RRC) protocol specification.”
[0026] FIGS. **1-3** below describe various embodiments implemented in wireless communications systems and with the use of orthogonal frequency division multiplexing (OFDM) or orthogonal frequency division multiple access (OFDMA) communication techniques. The descriptions of FIGS. **1-3** are not meant to imply physical or architectural limitations to how different embodiments may be implemented. Different embodiments of the present disclosure may be implemented in any suitably arranged communications system.
[0027] FIG. **1** illustrates an example wireless network **100** according to embodiments of the present disclosure. The embodiment of the wireless network **100** shown in FIG. **1** is for illustration only. Other embodiments of the wireless network **100** could be used without departing from the scope of this disclosure.
[0028] As shown in FIG. **1**, the wireless network **100** includes a gNB **101** (e.g., base station, BS), a

gNB **102**, and a gNB **103**. The gNB **101** communicates with the gNB **102** and the gNB **103**. The gNB **101** also communicates with at least one network **130**, such as the Internet, a proprietary Internet Protocol (IP) network, or other data network.

[0029] The gNB **102** provides wireless broadband access to the network **130** for a first plurality of user equipments (UEs) within a coverage area **120** of the gNB **102**. The first plurality of UEs includes a UE **111**, which may be located in a small business; a UE **112**, which may be located in an enterprise; a UE **113**, which may be a WiFi hotspot; a UE **114**, which may be located in a first residence; a UE **115**, which may be located in a second residence; and a UE **116**, which may be a mobile device, such as a cell phone, a wireless laptop, a wireless PDA, or the like. The gNB **103** provides wireless broadband access to the network **130** for a second plurality of UEs within a coverage area **125** of the gNB **103**. The second plurality of UEs includes the UE **115** and the UE **116**. In some embodiments, one or more of the gNBs **101-103** may communicate with each other and with the UEs **111-116** using 5G/NR, long term evolution (LTE), long term evolution-advanced (LTE-A), WiMAX, WiFi, or other wireless communication techniques.

[0030] Depending on the network type, the term “base station” or “BS” can refer to any component (or collection of components) configured to provide wireless access to a network, such as transmit point (TP), transmit-receive point (TRP), an enhanced base station (eNodeB or eNB), a 5G/NR base station (gNB), a macrocell, a femtocell, a WiFi access point (AP), or other wirelessly enabled devices. Base stations may provide wireless access in accordance with one or more wireless communication protocols, e.g., 5G/NR 3.sup.rd generation partnership project (3GPP) NR, long term evolution (LTE), LTE advanced (LTE-A), high speed packet access (HSPA), Wi-Fi 802.11a/b/g/n/ac, etc. For the sake of convenience, the terms “BS” and “TRP” are used interchangeably in this patent document to refer to network infrastructure components that provide wireless access to remote terminals. Also, depending on the network type, the term “user equipment” or “UE” can refer to any component such as “mobile station,” “subscriber station,” “remote terminal,” “wireless terminal,” “receive point,” or “user device.” For the sake of convenience, the terms “user equipment” and “UE” are used in this patent document to refer to remote wireless equipment that wirelessly accesses a BS, whether the UE is a mobile device (such as a mobile telephone or smartphone) or is normally considered a stationary device (such as a desktop computer or vending machine).

[0031] The dotted lines show the approximate extents of the coverage areas **120** and **125**, which are shown as approximately circular for the purposes of illustration and explanation only. It should be clearly understood that the coverage areas associated with gNBs, such as the coverage areas **120** and **125**, may have other shapes, including irregular shapes, depending upon the configuration of the gNBs and variations in the radio environment associated with natural and man-made obstructions.

[0032] As described in more detail below, one or more of the UEs **111-116** include circuitry, programing, or a combination thereof for using patterns for SSBs. In certain embodiments, one or more of the BSs **101-103** include circuitry, programing, or a combination thereof to support patterns for SSBs.

[0033] Although FIG. **1** illustrates one example of a wireless network, various changes may be made to FIG. **1**. For example, the wireless network **100** could include any number of gNBs and any number of UEs in any suitable arrangement. Also, the gNB **101** could communicate directly with any number of UEs and provide those UEs with wireless broadband access to the network **130**. Similarly, each gNB **102-103** could communicate directly with the network **130** and provide UEs with direct wireless broadband access to the network **130**. Further, the gNBs **101**, **102**, and/or **103** could provide access to other or additional external networks, such as external telephone networks or other types of data networks.

[0034] FIG. **2** illustrates an example gNB **102** according to embodiments of the present disclosure. The embodiment of the gNB **102** illustrated in FIG. **2** is for illustration only, and the gNBs **101** and

103 of FIG. **1** could have the same or similar configuration. However, gNBs come in a wide variety of configurations, and FIG. **2** does not limit the scope of this disclosure to any particular implementation of a gNB.

[0035] As shown in FIG. **2**, the gNB **102** includes multiple antennas **205***a*-**205***n*, multiple transceivers **210***a*-**210***n*, a controller/processor **225**, a memory **230**, and a backhaul or network interface **235**.

[0036] The transceivers **210***a*-**210***n* receive, from the antennas **205***a*-**205***n*, incoming radio frequency (RF) signals, such as signals transmitted by UEs in the wireless network **100**. The transceivers **210***a*-**210***n* down-convert the incoming RF signals to generate IF or baseband signals. The IF or baseband signals are processed by receive (RX) processing circuitry in the transceivers **210***a*-**210***n* and/or controller/processor **225**, which generates processed baseband signals by filtering, decoding, and/or digitizing the baseband or IF signals. The controller/processor **225** may further process the baseband signals.

[0037] Transmit (TX) processing circuitry in the transceivers **210***a*-**210***n* and/or controller/processor **225** receives analog or digital data (such as voice data, web data, e-mail, or interactive video game data) from the controller/processor **225**. The TX processing circuitry encodes, multiplexes, and/or digitizes the outgoing baseband data to generate processed baseband or IF signals. The transceivers **210***a*-**210***n* up-converts the baseband or IF signals to RF signals that are transmitted via the antennas **205***a*-**205***n*.

[0038] The controller/processor **225** can include one or more processors or other processing devices that control the overall operation of the gNB **102**. For example, the controller/processor **225** could control the reception of uplink (UL) channel signals and the transmission of downlink (DL) channel signals by the transceivers **210***a*-**210***n* in accordance with well-known principles. The controller/processor **225** could support additional functions as well, such as more advanced wireless communication functions. For instance, the controller/processor **225** could support beam forming or directional routing operations in which outgoing/incoming signals from/to multiple antennas **205***a*-**205***n* are weighted differently to effectively steer the outgoing signals in a desired direction. As another example, the controller/processor **225** could support methods for patterns for SSBs. Any of a wide variety of other functions could be supported in the gNB **102** by the controller/processor **225**.

[0039] The controller/processor **225** is also capable of executing programs and other processes resident in the memory **230**, such as processes related to supporting patterns for SSBs. The controller/processor **225** can move data into or out of the memory **230** as required by an executing process.

[0040] The controller/processor **225** is also coupled to the backhaul or network interface **235**. The backhaul or network interface **235** allows the gNB **102** to communicate with other devices or systems over a backhaul connection or over a network. The interface **235** could support communications over any suitable wired or wireless connection(s). For example, when the gNB **102** is implemented as part of a cellular communication system (such as one supporting 5G/NR, LTE, or LTE-A), the interface **235** could allow the gNB **102** to communicate with other gNBs over a wired or wireless backhaul connection. When the gNB **102** is implemented as an access point, the interface **235** could allow the gNB **102** to communicate over a wired or wireless local area network or over a wired or wireless connection to a larger network (such as the Internet). The interface **235** includes any suitable structure supporting communications over a wired or wireless connection, such as an Ethernet or transceiver.

[0041] The memory **230** is coupled to the controller/processor **225**. Part of the memory **230** could include a RAM, and another part of the memory **230** could include a Flash memory or other ROM.

[0042] Although FIG. **2** illustrates one example of gNB **102**, various changes may be made to FIG. **2**. For example, the gNB **102** could include any number of each component shown in FIG. **2**. Also, various components in FIG. **2** could be combined, further subdivided, or omitted and additional components could be added according to particular needs.

[0043] FIG. **3** illustrates an example UE **116** according to embodiments of the present disclosure. The embodiment of the UE **116** illustrated in FIG. **3** is for illustration only, and the UEs **111-115** of FIG. **1** could have the same or similar configuration. However, UEs come in a wide variety of configurations, and FIG. **3** does not limit the scope of this disclosure to any particular implementation of a UE.

[0044] As shown in FIG. **3**, the UE **116** includes antenna(s) **305**, a transceiver(s) **310**, and a microphone **320**. The UE **116** also includes a speaker **330**, a processor **340**, an input/output (I/O) interface (IF) **345**, an input **350**, a display **355**, and a memory **360**. The memory **360** includes an operating system (OS) **361** and one or more applications **362**.

[0045] The transceiver(s) **310** receives from the antenna(s) **305**, an incoming RF signal transmitted by a gNB of the wireless network **100**. The transceiver(s) **310** down-converts the incoming RF signal to generate an intermediate frequency (IF) or baseband signal. The IF or baseband signal is processed by RX processing circuitry in the transceiver(s) **310** and/or processor **340**, which generates a processed baseband signal by filtering, decoding, and/or digitizing the baseband or IF signal. The RX processing circuitry sends the processed baseband signal to the speaker **330** (such as for voice data) or is processed by the processor **340** (such as for web browsing data).

[0046] TX processing circuitry in the transceiver(s) **310** and/or processor **340** receives analog or digital voice data from the microphone **320** or other outgoing baseband data (such as web data, e-mail, or interactive video game data) from the processor **340**. The TX processing circuitry encodes, multiplexes, and/or digitizes the outgoing baseband data to generate a processed baseband or IF signal. The transceiver(s) **310** up-converts the baseband or IF signal to an RF signal that is transmitted via the antenna(s) **305**.

[0047] The processor **340** can include one or more processors or other processing devices and execute the OS **361** stored in the memory **360** in order to control the overall operation of the UE **116**. For example, the processor **340** could control the reception of DL channel signals and the transmission of UL channel signals by the transceiver(s) **310** in accordance with well-known principles. In some embodiments, the processor **340** includes at least one microprocessor or microcontroller.

[0048] The processor **340** is also capable of executing other processes and programs resident in the memory **360**. For example, the processor **340** may execute processes for identifying and using patterns for SSBs as described in embodiments of the present disclosure. The processor **340** can move data into or out of the memory **360** as required by an executing process. In some embodiments, the processor **340** is configured to execute the applications **362** based on the OS **361** or in response to signals received from gNBs or an operator. The processor **340** is also coupled to the I/O interface **345**, which provides the UE **116** with the ability to connect to other devices, such as laptop computers and handheld computers. The I/O interface **345** is the communication path between these accessories and the processor **340**.

[0049] The processor **340** is also coupled to the input **350**, which includes, for example, a touchscreen, keypad, etc., and the display **355**. The operator of the UE **116** can use the input **350** to enter data into the UE **116**. The display **355** may be a liquid crystal display, light emitting diode display, or other display capable of rendering text and/or at least limited graphics, such as from web sites.

[0050] The memory **360** is coupled to the processor **340**. Part of the memory **360** could include a random-access memory (RAM), and another part of the memory **360** could include a Flash memory or other read-only memory (ROM).

[0051] Although FIG. **3** illustrates one example of UE **116**, various changes may be made to FIG. **3**. For example, various components in FIG. **3** could be combined, further subdivided, or omitted and additional components could be added according to particular needs. As a particular example, the processor **340** could be divided into multiple processors, such as one or more central processing units (CPUs) and one or more graphics processing units (GPUs). In another example, the transceiver(s) **310** may include any number of transceivers and signal processing chains and may be connected to any number of antennas. Also, while FIG. **3** illustrates the UE **116** configured as a mobile telephone or smartphone, UEs could be configured to operate as other types of mobile or stationary devices.

[0052] FIG. **4**A and FIG. **4**B illustrate an example of wireless transmit and receive paths **400** and **450**, respectively, according to embodiments of the present disclosure. For example, a transmit path **400** may be described as being implemented in a gNB (such as gNB **102**), while a receive path **450** may be described as being implemented in a UE (such as UE **116**). However, it will be understood that the receive path **450** can be implemented in a gNB and that the transmit path **400** can be implemented in a UE. In some embodiments, the transmit path **400** and/or receive path **450** is configured for patterns for SSBs as described in embodiments of the present disclosure.

[0053] As illustrated in FIG. **4**A, the transmit path **400** includes a channel coding and modulation block **405**, a serial-to-parallel (S-to-P) block **410**, a size N Inverse Fast Fourier Transform (IFFT) block **415**, a parallel-to-serial (P-to-S) block **420**, an add cyclic prefix block **425**, and an up-converter (UC) **430**. The receive path **450** includes a down-converter (DC) **455**, a remove cyclic prefix block **460**, a S-to-P block **465**, a size N Fast Fourier Transform (FFT) block **470**, a parallel-to-serial (P-to-S) block **475**, and a channel decoding and demodulation block **480**.

[0054] In the transmit path **400**, the channel coding and modulation block **405** receives a set of information bits, applies coding (such as a low-density parity check (LDPC) coding), and modulates the input bits (such as with Quadrature Phase Shift Keying (QPSK) or Quadrature Amplitude Modulation (QAM)) to generate a sequence of frequency-domain modulation symbols. The serial-to-parallel block **410** converts (such as de-multiplexes) the serial modulated symbols to parallel data in order to generate N parallel symbol streams, where N is the IFFT/FFT size used in the gNB **102** and the UE **116**. The size N IFFT block **415** performs an IFFT operation on the N parallel symbol streams to generate time-domain output signals. The parallel-to-serial block **420** converts (such as multiplexes) the parallel time-domain output symbols from the size N IFFT block **415** in order to generate a serial time-domain signal. The add cyclic prefix block **425** inserts a cyclic prefix to the time-domain signal. The up-converter **430** modulates (such as up-converts) the output of the add cyclic prefix block **425** to a RF frequency for transmission via a wireless channel. The signal may also be filtered at a baseband before conversion to the RF frequency.

[0055] As illustrated in FIG. **4**B, the down-converter **455** down-converts the received signal to a baseband frequency, and the remove cyclic prefix block **460** removes the cyclic prefix to generate a serial time-domain baseband signal. The serial-to-parallel block **465** converts the time-domain baseband signal to parallel time-domain signals. The size N FFT block **470** performs an FFT algorithm to generate N parallel frequency-domain signals. The (P-to-S) block **475** converts the parallel frequency-domain signals to a sequence of modulated data symbols. The channel decoding and demodulation block **480** demodulates and decodes the modulated symbols to recover the original input data stream.

[0056] Each of the gNBs **101-103** may implement a transmit path **400** that is analogous to transmitting in the downlink to UEs **111-116** and may implement a receive path **450** that is analogous to receiving in the uplink from UEs **111-116**. Similarly, each of UEs **111-116** may implement a transmit path **400** for transmitting in the uplink to gNBs **101-103** and may implement a receive path **450** for receiving in the downlink from gNBs **101-103**.

[0057] Each of the components in FIGS. **4**A and **4**B can be implemented using only hardware or using a combination of hardware and software/firmware. As a particular example, at least some of the components in FIGS. **4**A and **4**B may be implemented in software, while other components may be implemented by configurable hardware or a mixture of software and configurable hardware. For instance, the FFT block **470** and the IFFT block **415** may be implemented as configurable software algorithms, where the value of size N may be modified according to the implementation.

[0058] Furthermore, although described as using FFT and IFFT, this is by way of illustration only and should not be construed to limit the scope of the present disclosure. Other types of transforms, such as Discrete Fourier Transform (DFT) and Inverse Discrete Fourier Transform (IDFT) functions, can be used. It will be appreciated that the value of the variable N may be any integer number (such as 1, 2, 3, 4, or the like) for DFT and IDFT functions, while the value of the variable N may be any integer number that is a power of two (such as 1, 2, 4, 8, 16, or the like) for FFT and IFFT functions.

[0059] Although FIGS. **4**A and **4**B illustrate examples of wireless transmit and receive paths **400** and **450**, respectively, various changes may be made to FIGS. **4**A and **4**B. For example, various components in FIGS. **4**A and **4**B can be combined, further subdivided, or omitted and additional components can be added according to particular needs. Also, FIGS. **4**A and **4**B are meant to illustrate examples of the types of transmit and receive paths that can be used in a wireless network. Any other suitable architectures can be used to support wireless communications in a wireless network.

[0060] Although exemplary descriptions and embodiments to follow assume orthogonal frequency division multiplexing (OFDM) or orthogonal frequency division multiple access (OFDMA), this disclosure can be extended to other OFDM-based transmission waveforms or multiple access schemes such as filtered OFDM (F-OFDM).

[0061] The present disclosure covers several components which can be used in conjunction or in combination with one another, or can operate as standalone schemes.

[0062] In typical NR, for a secondary cell (SCell) implemented with periodic synchronization signal/physical broadcast channel (SS/PBCH) block transmission, a UE (e.g., the UE **116**) can be provided with a configuration for radio resource management (RRM) measurement based on the periodic SS/PBCH block, wherein the configuration can be provided by a RRC parameter. After the RRM measurement, the gNB (e.g., the BS **102**) can provide a configuration of the SCell, e.g., by another RRC parameter. The UE can be further provided with a MAC CE indicating an activation of the SCell, and by using the periodic SS/PBCH blocks on the SCell, or tracking reference signal (TRS) if configured, or the SS/PBCH blocks on the primary cell (PCell) when the SCell is without periodic SS/PBCH block transmission, the UE can get synchronized with the SCell and get ready to transmit or receive on the SCell. After activation of the SCell, if the SCell gets loss of synchronization, the UE can use the periodic SS/PBCH block for resynchronization. Since SS/PBCH block is transmitted on the SCell periodically, the power consumption for SS/PBCH block can be significantly large. Embodiments of the present disclosure recognizes that there is a need to reduce the power consumption. On-demand SSB can be supported on the SCell.

[0063] To further reduce the power of on-demand SSB on a SCell, the structure of on-demand SSB can be simplified from typical SSB, and the pattern of the SSB (e.g. pattern in the time domain) can also be modified accordingly. For a further step, the structure of the on-demand SSB and/or the pattern of the SSB can be flexible and configurable. The embodiments and examples of this disclosure, although motivated by on-demand SSB on a SCell, can be applicable to SS/PBCH block with and/or without a periodic transmission manner, and can be applicable to SS/PBCH block in a PCell, SCell, of primary secondary cell (PSCell).

[0064] This disclosure focuses on a pattern of SS/PBCH block as on-demand SSB. More precisely, the following aspects are included in the disclosure: [0065] New SSB pattern for on-demand SSB [0066] Using 1 slot as design unit [0067] Using 2 slots as design unit [0068] Using 4 slots as design unit [0069] Extending the number of SSB in the SSB pattern [0070] SSB validation for on-demand SSB [0071] Configurable SSB pattern

[0072] FIG. **5** illustrates a diagram of example on-demand SSB patterns **500** according to embodiments of the present disclosure. For example, on-demand SSB patterns **500** can be utilized by any of the UEs **111-116** of FIG. **1**. This example is for illustration only and other embodiments can be used without departing from the scope of the present disclosure.

[0073] In one embodiment, the first symbol indexes for candidate SS/PBCH blocks (SSBs) can be determined as S+14.Math.n, wherein S is the set of symbol indexes as the first symbol indexes for candidate SSBs within a slot. The pattern of the symbol indexes for the candidate SSBs is denoted as one example SSB pattern in this embodiment, and e.g., the SSB pattern can be applicable at least for on-demand SSB.

[0074] Examples for this embodiment are shown in FIG. **5**, wherein a number of symbols for a SSB is 2. For one sub-example, the 2 symbols are mapped for primary synchronization signal (PSS) and second synchronization signal (SSS). For another sub-example, the 2 symbols are mapped for PSS frequency division multiplexed (FDMed) with PBCH, and SSS FDMed PBCH.

[0075] In a first example (Example 1 in FIG. **5**), the set S={0, 2, 4, 6, 8, 10, 12}, and a number of candidate SSBs in a slot is 7.

[0076] In a second example (Example 2 in FIG. **5**), the set S={2, 4, 6, 8, 10, 12}, and a number of candidate SSBs in a slot is 6.

[0077] In a third example (Example 3 in FIG. **5**), the set S={0, 2, 4, 6, 8, 10}, and a number of candidate SSBs in a slot is 6.

[0078] In a forth example (Example 4 in FIG. **5**), the set S={2, 4, 6, 8, 10}, and a number of candidate SSBs in a slot is 5.

[0079] In a fifth example (Example 5 in FIG. **5**), the set S={2, 4, 8, 10}, and a number of candidate SSBs in a slot is 4.

[0080] In a sixth example (Example 6 in FIG. **5**), the set S={1, 3, 5, 7, 9, 11}, and a number of candidate SSBs in a slot is 6.

[0081] In a seventh example (Example 7 in FIG. **5**), the set S={0, 2, 4, 7, 9, 11}, and a number of candidate SSBs in a slot is 6.

[0082] In an eighth example (Example 8 in FIG. **5**), the set S={1, 3, 5, 8, 10, 12}, and a number of candidate SSBs in a slot is 6.

[0083] In a ninth example (Example 9 in FIG. **5**), the set S={2, 4, 9, 11}, and a number of candidate SSBs in a slot is 4.

[0084] For one further evaluation of the examples of this embodiment, the SSB pattern can be applicable for at least one subcarrier spacing (SCS) of the SSB. [0085] For one instance, the SSB pattern can be applicable for a SCS of the SSB as 15 kHz. [0086] For another instance, the SSB pattern can be applicable for a SCS of the SSB as 30 KHz. [0087] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 60 kHz. [0088] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 120 kHz. [0089] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 240 kHz. [0090] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 480 kHz. [0091] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 960 kHz.

[0092] For another further evaluation of the examples of this embodiment, the SSB pattern can be applicable for at least one frequency range. [0093] For one instance, the SSB pattern can be applicable for FR1. [0094] For another instance, the SSB pattern can be applicable for FR2-1. [0095] For yet another instance, the SSB pattern can be applicable for FR2-2.

[0096] FIG. **6** illustrates a diagram of example on-demand SSB patterns **600** according to embodiments of the present disclosure. For example, on-demand SSB patterns **600** can be utilized by any of the UEs **111-116** of FIG. **1**, such as the UE **111**. This example is for illustration only and other embodiments can be used without departing from the scope of the present disclosure.

[0097] In one embodiment, the first symbol indexes for candidate SS/PBCH blocks (SSBs) can be determined as S+28.Math.n, wherein S is the set of symbol indexes as the first symbol indexes for candidate SSBs within two consecutive slots. The pattern of the symbol indexes for the candidate SSBs is denoted as SSB pattern in this embodiment, and e.g., the SSB pattern can be applicable at least for on-demand SSB.

[0098] Examples for this embodiment are shown in FIG. **6**, wherein a number of symbols for a SSB is 2. For one sub-example, the 2 symbols are mapped for primary synchronization signal (PSS) and second synchronization signal (SSS). For another sub-example, the 2 symbols are mapped for PSS frequency division multiplexed (FDMed) with PBCH, and SSS FDMed PBCH.
[0099] In a first example (Example 1 in FIG. **6**), the set S={4, 6, 8, 10, 16, 18, 20, 22}, and a number of candidate SSBs in two consecutive slots is 8.
[0100] In a second example (Example 2 in FIG. **6**), the set S={4, 6, 8, 10, 12, 14, 16, 18, 20, 22}, and a number of candidate SSBs in two consecutive slots is 10.
[0101] In a third example (Example 3 in FIG. **6**), the set S={0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22}, and a number of candidate SSBs in two consecutive slots is 12.
[0102] In a forth example (Example 4 in FIG. **6**), the set S={0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24}, and a number of candidate SSBs in two consecutive slots is 13.
[0103] In a fifth example (Example 5 in FIG. **6**), the set S={2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24}, and a number of candidate SSBs in two consecutive slots is 12.
[0104] For one further evaluation of the examples of this embodiment, the SSB pattern can be applicable for at least one SCS of the SSB. [0105] For one instance, the SSB pattern can be applicable for a SCS of the SSB as 15 kHz. [0106] For another instance, the SSB pattern can be applicable for a SCS of the SSB as 30 kHz. [0107] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 60 kHz. [0108] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 120 kHz. [0109] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 240 kHz. [0110] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 480 kHz. [0111] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 960 kHz.
[0112] For another further evaluation of the examples of this embodiment, the SSB pattern can be applicable for at least one frequency range. [0113] For one instance, the SSB pattern can be applicable for FR1. [0114] For another instance, the SSB pattern can be applicable for FR2-1. [0115] For yet another instance, the SSB pattern can be applicable for FR2-2.
[0116] FIG. **7** illustrates a diagram of example on-demand SSB patterns **700** according to embodiments of the present disclosure. For example, on-demand SSB patterns **700** can be utilized by any of the UEs **111-116** of FIG. **1**, such as the UE **116**. This example is for illustration only and other embodiments can be used without departing from the scope of the present disclosure.
[0117] In one embodiment, the first symbol indexes for candidate SS/PBCH blocks (SSBs) can be determined as S+56.Math.n, wherein S is the set of symbol indexes as the first symbol indexes for candidate SSBs within two consecutive slots. The pattern of the symbol indexes for the candidate SSBs is denoted as SSB pattern in this embodiment, and e.g., the SSB pattern can be applicable at least for on-demand SSB.
[0118] Examples for this embodiment are shown in FIG. **7**, wherein a number of symbols for a SSB is 2. For one sub-example, the 2 symbols are mapped for primary synchronization signal (PSS) and second synchronization signal (SSS). For another sub-example, the 2 symbols are mapped for PSS frequency division multiplexed (FDMed) with PBCH, and SSS FDMed PBCH.
[0119] In a first example (Example 1 in FIG. **7**), the set S={8, 10, 12, 14, 16, 18, 20, 22, 32, 34, 36, 38, 40, 42, 44, 46}, and a number of candidate SSBs in two consecutive slots is 16.
[0120] In a second example (Example 2 in FIG. **7**), the set S={8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46}, and a number of candidate SSBs in two consecutive slots is 20.
[0121] In a third example (Example 3 in FIG. **7**), the set S={0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46}, and a number of candidate SSBs in two consecutive slots is 24.
[0122] In a forth example (Example 4 in FIG. **7**), the set S={0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50}, and a number of candidate SSBs in two

consecutive slots is 26.
[0123] In a fifth example (Example 5 in FIG. **7**), the set S={4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50}, and a number of candidate SSBs in two consecutive slots is 24.
[0124] In a sixth example (Example 6 in FIG. **7**), the set S={0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52}, and a number of candidate SSBs in two consecutive slots is 27.
[0125] In a seventh example (Example 7 in FIG. **7**), the set S={2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52}, and a number of candidate SSBs in two consecutive slots is 26.
[0126] For one further evaluation of the examples of this embodiment, the SSB pattern can be applicable for at least one SCS of the SSB. [0127] For one instance, the SSB pattern can be applicable for a SCS of the SSB as 15 kHz. [0128] For another instance, the SSB pattern can be applicable for a SCS of the SSB as 30 kHz. [0129] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 60 kHz. [0130] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 120 kHz. [0131] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 240 kHz. [0132] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 480 kHz. [0133] For yet another instance, the SSB pattern can be applicable for a SCS of the SSB as 960 kHz.
[0134] For another further evaluation of the examples of this embodiment, the SSB pattern can be applicable for at least one frequency range. [0135] For one instance, the SSB pattern can be applicable for FR1. [0136] For another instance, the SSB pattern can be applicable for FR2-1. [0137] For yet another instance, the SSB pattern can be applicable for FR2-2.
[0138] In one embodiment, the number of candidate SS/PBCH blocks in a burst can be extended. For example, the extension of the number of candidate SS/PBCH blocks in a burst can be applicable at least for on-demand SSB. For another example, the extension of the number of candidate SS/PBCH blocks in a burst can be applicable to periodic SSB.
[0139] For one example, the number of candidate SS/PBCH blocks can be extended such that the candidate SS/PBCH blocks are located across half frame boundary (e.g., the candidate SS/PBCH block burst is longer than a half frame).
[0140] For another example, the number of candidate SS/PBCH blocks can be extended such that the candidate SS/PBCH blocks are located within a half frame (e.g., the candidate SS/PBCH block burst is no longer than a half frame).
[0141] For yet another example, the number of candidate SS/PBCH blocks can be extended such that the candidate SS/PBCH blocks are located in slots within a half frame (e.g., the candidate SS/PBCH block burst equals to a half frame).
[0142] For one example, the starting symbol in a SSB pattern can be same as the one in Rel-15/16/17/18 or NR, and only the value of n in the SSB pattern is extended comparing to Rel-15/16/17/18 or NR.
[0143] For another example, the starting symbol in a SSB pattern can be according to an example as in this disclosure, and the value of n in the SSB pattern is determined such that the maximum number of candidate SSB is same as L.sub.max.
[0144] For yet another example, the starting symbol in a SSB pattern can be according to an example as in this disclosure, and the value of n in the SSB pattern is extended such that the maximum number of candidate SSB larger than L.sub.max as in Rel-15/16/17/18 or NR.
[0145] For one example, a UE expects a number L.sub.max of SSB are transmitted out of the L.sub.max candidate SSB occasions.
[0146] FIG. **8** illustrates a flowchart of an example UE procedure **800** for receiving an on-demand SSB according to embodiments of the present disclosure. For example, procedure **800** can be performed by the UE **116** of FIG. **3**. This example is for illustration only and other embodiments

can be used without departing from the scope of the present disclosure.
[0147] The procedure begins in **801**, a UE determines a SSB pattern based on a SCS and frequency range. In **802**, the UE determines valid SSB occasions. In **803**, the UE receives on-demand SSB according to the valid SSB occasions.
[0148] In one embodiment, part or each of the candidate SSB occasions can be determined as valid for on-demand SSB transmission, according to at least one example of this embodiment.
[0149] For one example, a candidate SSB for on-demand SSB transmission overlapping or partially overlapping with a periodic SSB is regarded as not valid or expected to be not transmitted.
[0150] For another example, if a candidate SSB for on-demand SSB transmission overlaps or partially overlaps with a periodic SSB, the periodic SSB is expected to be not transmitted.
[0151] For yet another example, the UE expects a candidate SSB for on-demand SSB transmission do not overlap with a periodic SSB.
[0152] For one example, a candidate SSB for on-demand SSB transmission overlapping or partially overlapping with a RE for TRS is not valid. For instance, the TRS can be configured for the SCell activation.
[0153] For another example, if a candidate SSB for on-demand SSB transmission overlaps or partially overlaps with a RE for TRS, the TRS is expected to be not transmitted. For instance, the TRS can be configured for the SCell activation.
[0154] For yet another example, if a candidate SSB for on-demand SSB transmission overlaps or partially overlaps with a RE for TRS, the TRS is expected to be not transmitted on the REs that overlap or partially overlap with the candidate SSB. For instance, the TRS can be configured for the SCell activation.
[0155] For yet another example, the UE expects that REs for a candidate SSB for on-demand SSB transmission do not overlap with REs for TRS. For instance, the TRS can be configured for the SCell activation.
[0156] For one example, a candidate SSB for on-demand SSB transmission overlapping or partially overlapping with a CORESET is not valid. For one instance, the CORESET can be at least for Type0 physical downlink control channel Type0-PDCCH monitoring.
[0157] For another example, a candidate SSB for on-demand SSB transmission overlapping or partially overlapping with a physical downlink control channel (PDCCH) in a CORESET is not valid. For one instance, the CORESET can be at least for Type0-PDCCH monitoring.
[0158] For yet another example, if a candidate SSB for on-demand SSB transmission overlaps or partially overlaps with a CORESET, the PDCCH in the CORESET is expected to be not transmitted. For one instance, the CORESET can be at least for Type0-PDCCH monitoring.
[0159] For yet another example, if a candidate SSB for on-demand SSB transmission overlaps or partially overlaps with a RE for a CORESET, the PDCCH in the CORESET is expected to be not transmitted on the REs that overlap or partially overlap with the candidate SSB. For one instance, the CORESET can be at least for Type0-PDCCH monitoring.
[0160] For yet another example, the UE expects that REs for a candidate SSB for on-demand SSB transmission do not overlap with REs for a CORESET. For one instance, the CORESET can be at least for Type0-PDCCH monitoring.
[0161] For one example, a candidate SSB for on-demand SSB transmission overlapping or partially overlapping with a RE for an uplink transmission is not valid. For instance, the uplink transmission can be a physical random access channel (PRACH), or a physical uplink control channel (PUCCH), or a physical uplink shared channel (PUSCH), or a SRS.
[0162] For another example, if a candidate SSB for on-demand SSB transmission overlaps or partially overlaps with a RE for an uplink transmission, the uplink transmission is expected to be not transmitted. For instance, the uplink transmission can be a PRACH, or a PUCCH, or a PUSCH, or a sounding reference signal (SRS).
[0163] For yet another example, if a candidate SSB for on-demand SSB transmission overlaps or

partially overlaps with a RE for an uplink transmission, the uplink transmission is expected to be not transmitted on the REs that overlap or partially overlap with the candidate SSB. For instance, the uplink transmission can be a PRACH, or a PUCCH, or a PUSCH, or a SRS.
[0164] For yet another example, the UE expects that REs for a candidate SSB for on-demand SSB transmission do not overlap with REs for an uplink transmission. For one instance, the uplink transmission can be a PRACH, or a PUCCH, or a PUSCH, or a SRS.
[0165] For one example, if a candidate SSB for on-demand SSB transmission overlaps or partially overlaps with a symbol that is indicated as uplink (e.g., by a RRC parameter indicating the slot format, and/or by a downlink control information (DCI) indicating the slot format), the candidate SSB is not valid for on-demand SSB transmission.
[0166] For another example, if a candidate SSB for on-demand SSB transmission overlaps or partially overlaps with a symbol that is not indicated as downlink (e.g., by a RRC parameter indicating the slot format, and/or by a DCI indicating the slot format), the candidate SSB is not valid for on-demand SSB transmission.
[0167] For one example, if a candidate SSB for on-demand SSB transmission overlaps or partially overlaps with a symbol that is indicated for uplink transmission (e.g., by a DCI indicating an uplink transmission), the candidate SSB is not valid for on-demand SSB transmission.
[0168] For one example, if a candidate SSB for on-demand SSB transmission overlaps or partially overlaps with a symbol that is scheduled or configured for uplink transmission (e.g., configured PUSCH), the candidate SSB is not valid for on-demand SSB transmission.
[0169] An example UE procedure for SSB pattern and validation is shown in FIG. **8**.
[0170] In one embodiment, a pattern for SS/PBCH block can be configurable. For one further evaluation, multiple candidate patterns for SS/PBCH block can be pre-defined in the specification for system operation and at least one of them can be configured, e.g., by higher layer parameter. For another further evaluation, at least one of the following parameters for the pattern for SS/PBCH block can be configured.
[0171] For a first example, a (maximum) number of (candidate) SS/PBCH block in a burst.
[0172] For a second example, actually transmitted SS/PBCH block in a burst. For one further evaluation, a UE (e.g., the UE **116**) can determine a number of actually transmitted SS/PBCH block in a burst based on the actually transmitted SS/PBCH block in a burst.
[0173] For a third example, at least one time domain gap between two consecutive SS/PBCH blocks in a burst. For one instance, the at least one time domain gap can be in a number of OFDM symbols. For another instance, when the at least one time domain gap is configured as 0, or the time domain gap is not configured, a default value can be expected by a UE, e.g., a default value can be 0, or a default value can be determined based on a default pattern of SS/PBCH block. For yet another instance, the time domain gap may not be unique for all the SS/PBCH blocks in the burst, and the time domain gap can be determined by the starting symbols of the candidate SS/PBCH blocks in a burst.
[0174] For a fourth example, a SS/PBCH block structure. For one instance, the SS/PBCH block structure includes a number of OFDM symbols of the SS/PBCH block. For another instance, the SS/PBCH block structure includes a number of subcarriers or resource blocks as a bandwidth of the SS/PBCH block. For yet another instance, the SS/PBCH block structure includes which signal and/or channel is included in the SS/PBCH block structure, and/or how the signal and/or channel are multiplexed, wherein, e.g., the signal and/or channel can include primary synchronization signal (PSS), or secondary synchronization signal (SSS), or tertiary synchronization signal (TSS), or physical broadcast channel (PBCH), or additional PBCH, or demodulation reference signal (DM-RS) of PBCH, and/or the multiplexing method can be at least one or combination of time division multiplexing (TDM), frequency domain multiplexing (FDM), or interleaved frequency domain multiplexing (IFDM). For yet another instance, multiple candidate SS/PBCH block structures can be pre-defined in the specification for system operation and at least one of them can

be configured, e.g., by higher layer parameter.
[0175] For one example, at least one of the examples of this embodiments can formulate a pattern for the SS/PBCH block, wherein the pattern can be also associated with other time domain parameters as following: [0176] For one instance, a time location of SS/PBCH block burst. For one instance, the time location can be a half frame (within a periodicity) for SS/PBCH block burst, and/or slot(s) (within a periodicity) for SS/PBCH block burst. For another instance, the time location can be determined based on a reference timing and a time offset to the reference timing.
[0177] For another instance, a periodicity of the SS/PBCH block (or SS/PBCH block burst), which could also be referred to as a time domain interval between two neighboring SS/PBCH block bursts. For one instance, the candidate values of the periodicity to be configured can be {2.5, 5, 10, 20, 40, 80, 160, 320, 640, 1280} ms or its subset. For another instance, some additional candidate values of the periodicity to be configured can be {1, 2, 3, 4} ms or its subset. For yet another instance, some candidate values can be applicable for any cell, e.g., commonly configurable for any cell. For yet another instance, some candidate values can be applicable for SCell only, e.g., candidate values smaller than 5 ms, and/or candidate values larger than 160 ms. [0178] For yet another instance, a number of (transmitted) SS/PBCH block burst(s). For one instance, this example can be applicable when the SS/PBCH block transmission is not periodic, and/or activated by a trigger from the BS.
[0179] For one example, at least one of the examples of this embodiments can formulate a pattern for the SS/PBCH block, wherein the pattern can be also associated with parameters other than time domain parameters as following: [0180] For one instance, a subcarrier spacing of the SS/PBCH block. [0181] For another instance, a frequency location of the SS/PBCH block. [0182] For yet another instance, a physical cell ID associated with the SS/PBCH block. [0183] For yet another instance, a transmission power of the SS/PBCH block.
[0184] For one example, at least one pattern of the SS/PBCH block or at least one parameter of or associated with the pattern of the SS/PBCH block can be pre-defined in the specification, and a UE can be provided with a configuration on each or a subset of them, e.g., by system information and/or dedicated RRC parameter.
[0185] For another example, at least one pattern of the SS/PBCH block or at least one parameter of or associated with the pattern of the SS/PBCH block can be provided to the UE by system information and/or dedicated RRC parameter.
[0186] For yet another example, at least one pattern of the SS/PBCH block or at least one parameter of or associated with the pattern of the SS/PBCH block can be configured to a UE (e.g., as a set of candidates), and the UE can be provided with a MAC CE or a DCI format to activate at least one from the candidates.
[0187] For yet another example, at least one pattern of the SS/PBCH block or at least one parameter of or associated with the pattern of the SS/PBCH block can be reported by a UE as a UE capability.
[0188] For yet another example, at least one pattern of the SS/PBCH block or at least one parameter of or associated with the pattern of the SS/PBCH block can be provided by a UE using UE assistant information, e.g., to indicate the UE's preferred pattern and/or parameter.
[0189] For one example, this embodiment can be applicable to SS/PBCH block on a SCell or PSCell. For another example, this embodiment can be applicable to SS/PBCH block on a PCell. For yet another example, this embodiment can be applicable to SS/PBCH block associated with an operation mode (e.g., an energy saving mode, or a non-energy saving mode) of a cell.
[0190] For one example, this embodiment can be applicable to SS/PBCH block located on a frequency location not corresponding to any synchronization raster entry. For another example, this embodiment can be applicable to SS/PBCH block located on a frequency location corresponding to a synchronization raster entry. For yet another example, this embodiment can be applicable to SS/PBCH block with an associated system information block (e.g., system information block 1),

e.g., cell-defining SSB. For yet another example, this embodiment can be applicable to SS/PBCH block without an associated system information block (e.g., system information block 1), e.g., non-cell-defining SSB.

[0191] For one example, this embodiment can be applicable to on-demand SS/PBCH block. For another example, this embodiment can be applicable to periodic SS/PBCH block.

[0192] FIG. **9** illustrates an example method **900** performed by a UE in a wireless communication system according to embodiments of the present disclosure. The method **900** of FIG. **9** can be performed by any of the UEs **111-116** of FIG. **1**, such as the UE **116** of FIG. **3**, and a corresponding method can be performed by any of the BSs **101-103** of FIG. **1**, such as BS **102** of FIG. **2**. The method **900** is for illustration only and other embodiments can be used without departing from the scope of the present disclosure.

[0193] The method **900** begins with the UE receiving a set of higher layer parameters (**910**). The UE then identifies, based on the set of higher layer parameters, a set of configurations related to SS/PBCH blocks (**920**). For example, in **920**, the set of configurations include at least one of a time domain interval between two consecutive SS/PBCH blocks in a burst or an indication of a structure of the SS/PBCH blocks in the burst. In various embodiments, the set of configurations further include at least one of an indication of actually transmitted SS/PBCH blocks in the burst, time domain locations of bursts of the SS/PBCH blocks, and a periodicity for the bursts. In various embodiments, the set of configurations further include at least one of a frequency domain location of the SS/PBCH blocks, a subcarrier spacing of the SS/PBCH blocks, a physical cell identity associated with the SS/PBCH blocks, and a transmission power of the SS/PBCH blocks. In various embodiments, the frequency domain location does not correspond to a synchronization raster entry.

[0194] In various embodiments, the time domain interval is a number of OFDM symbols between two consecutive SS/PBCH blocks in the burst. In various embodiments, the structure of the SS/PBCH blocks includes at least one of a number of OFDM symbols in a SS/PBCH block of the SS/PBCH blocks, a bandwidth of the SS/PBCH block, and components of signals or channels included in the SS/PBCH block.

[0195] The UE then receives the SS/PBCH blocks based on the set of configurations (**930**). In various embodiments, the SS/PBCH blocks are associated with a SCell.

[0196] Any of the above variation embodiments can be utilized independently or in combination with at least one other variation embodiment. The above flowcharts illustrate example methods that can be implemented in accordance with the principles of the present disclosure and various changes could be made to the methods illustrated in the flowcharts herein. For example, while shown as a series of steps, various steps in each figure could overlap, occur in parallel, occur in a different order, or occur multiple times. In another example, steps may be omitted or replaced by other steps.

[0197] The above flowchart(s) illustrate example methods that can be implemented in accordance with the principles of the present disclosure and various changes could be made to the methods illustrated in the flowcharts herein. For example, while shown as a series of steps, various steps in each figure could overlap, occur in parallel, occur in a different order, or occur multiple times. In another example, steps may be omitted or replaced by other steps.

[0198] Any of the above variation embodiments can be utilized independently or in combination with at least one other variation embodiment. The above flowchart illustrates example methods that can be implemented in accordance with the principles of the present disclosure and various changes could be made to the methods illustrated in the flowchart herein. For example, while shown as a series of steps, various steps in each figure could overlap, occur in parallel, occur in a different order, or occur multiple times. In another example, steps may be omitted or replaced by other steps.

[0199] Although the present disclosure has been described with exemplary embodiments, various changes and modifications may be suggested to one skilled in the art. It is intended that the present disclosure encompass such changes and modifications as fall within the scope of the appended claims. None of the descriptions in this application should be read as implying that any particular element, step, or function is an essential element that must be included in the claims scope. The scope of patented subject matter is defined by the claims.

Claims

1. A user equipment (UE) in a wireless communication system, the UE comprising: a transceiver configured to receive a set of higher layer parameters; and a processor operably coupled to the transceiver, the processor configured to identify, based on the set of higher layer parameters, a set of configurations related to synchronization signals and physical broadcast channel (SS/PBCH) blocks, wherein the set of configurations include: a time domain interval between two consecutive SS/PBCH blocks in a burst; or an indication of a structure of the SS/PBCH blocks in the burst; wherein the transceiver is further configured to receive the SS/PBCH blocks based on the set of configurations.
2. The UE of claim 1, wherein the set of configurations further include: an indication of actually transmitted SS/PBCH blocks in the burst; time domain locations of bursts of the SS/PBCH blocks; and a periodicity for the bursts.
3. The UE of claim 1, wherein the set of configurations further include: a frequency domain location of the SS/PBCH blocks; a subcarrier spacing of the SS/PBCH blocks; a physical cell identity associated with the SS/PBCH blocks; and a transmission power of the SS/PBCH blocks.
4. The UE of claim 3, wherein the frequency domain location does not correspond to a synchronization raster entry.
5. The UE of claim 1, wherein the structure of the SS/PBCH blocks includes: a number of orthogonal frequency division multiplexing (OFDM) symbols in a SS/PBCH block of the SS/PBCH blocks; a bandwidth of the SS/PBCH block; or components of signals or channels included in the SS/PBCH block.
6. The UE of claim 1, wherein the time domain interval is a number of orthogonal frequency division multiplexing (OFDM) symbols between two consecutive SS/PBCH blocks in the burst.
7. The UE of claim 1, wherein the SS/PBCH blocks are associated with a secondary cell (SCell).
8. A base station (BS) in a wireless communication system, the BS comprising: a processor configured to: determine a set of configurations related to synchronization signals and physical broadcast channel (SS/PBCH) blocks, wherein the set of configurations include: a time domain interval between two consecutive SS/PBCH blocks in a burst; or an indication of a structure of the SS/PBCH blocks in the burst; and determine a set of higher layer parameters including the set of configurations; and a transceiver operably coupled to the processor, the transceiver configured to: transmit the set of higher layer parameters; and transmit the SS/PBCH blocks based on the set of configurations.
9. The BS of claim 8, wherein the set of configurations further include: an indication of actually transmitted SS/PBCH blocks in the burst; time domain locations of bursts of the SS/PBCH blocks; and a periodicity for the bursts.
10. The BS of claim 8, wherein the set of configurations further include: a frequency domain location of the SS/PBCH blocks; a subcarrier spacing of the SS/PBCH blocks; a physical cell identity associated with the SS/PBCH blocks; and a transmission power of the SS/PBCH blocks.
11. The BS of claim 10, wherein the frequency domain location does not correspond to a synchronization raster entry.
12. The BS of claim 8, wherein the structure of the SS/PBCH blocks includes: a number of orthogonal frequency division multiplexing (OFDM) symbols in a SS/PBCH block of the SS/PBCH blocks; a bandwidth of the SS/PBCH block; or components of signals or channels included in the SS/PBCH block.
13. The BS of claim 8, wherein the time domain interval is a number of orthogonal frequency division multiplexing (OFDM) symbols between two consecutive SS/PBCH blocks in the burst.

14. The BS of claim 8, wherein the SS/PBCH blocks are associated with a secondary cell (SCell).
15. A method of a user equipment (UE) in a wireless communication system, the method comprising: receiving a set of higher layer parameters; identifying, based on the set of higher layer parameters, a set of configurations related to synchronization signals and physical broadcast channel (SS/PBCH) blocks, wherein the set of configurations include: a time domain interval between two consecutive SS/PBCH blocks in a burst; or an indication of a structure of the SS/PBCH blocks in the burst; and receiving the SS/PBCH blocks based on the set of configurations.
16. The method of claim 15, wherein the set of configurations further include: an indication of actually transmitted SS/PBCH blocks in the burst; time domain locations of bursts of the SS/PBCH blocks; and a periodicity for the bursts.
17. The method of claim 15, wherein the set of configurations further include: a frequency domain location of the SS/PBCH blocks, wherein the frequency domain location does not correspond to a synchronization raster entry; a subcarrier spacing of the SS/PBCH blocks; a physical cell identity associated with the SS/PBCH blocks; and a transmission power of the SS/PBCH blocks.
18. The method of claim 15, wherein the structure of the SS/PBCH blocks includes: a number of orthogonal frequency division multiplexing (OFDM) symbols in a SS/PBCH block of the SS/PBCH blocks; a bandwidth of the SS/PBCH block; or components of signals or channels included in the SS/PBCH block.
19. The method of claim 15, wherein the time domain interval is a number of orthogonal frequency division multiplexing (OFDM) symbols between two consecutive SS/PBCH blocks in the burst.
20. The method of claim 15, wherein the SS/PBCH blocks are associated with a secondary cell (SCell).