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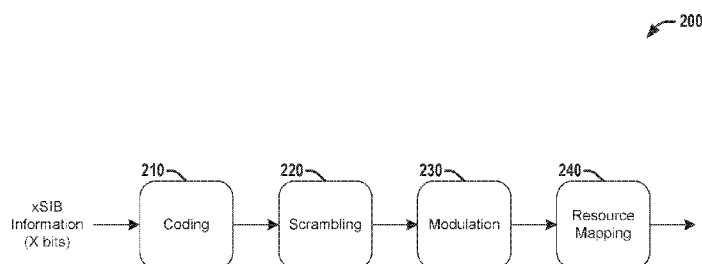
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SYSTEM INFORMATION BLOCK (xSIB)

FIG. 2

(57) Abstract: Techniques for transmitting Fifth Generation System Information Blocks (xSIBs) are discussed. In one embodiment, one or more processors can be configured to: generate a set of bits for a xSIB; apply coding to the set of bits to generate a coded set of bits; scramble the coded set of bits to generate a scrambled set of bits; modulate the scrambled set of bits to generate a modulated set of xSIB symbols; map the modulated set of xSIB symbols to a set of frequency domain resources to generate a physical xSIB channel; and output the physical xSIB channel to transceiver circuitry for transmission by a plurality of transmit (Tx) beams during a subframe, wherein the physical xSIB channel is output for transmission via one or more distinct Tx beams of the plurality during one or more of a plurality of distinct orthogonal frequency division multiplexing (OFDM) symbols of the subframe.

TRANSMISSION SCHEME AND INTER-CELL INTERFERENCE MITIGATION FOR FIFTH GENERATION (5G) SYSTEM INFORMATION BLOCK (xSIB)

REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/307,204 filed March 11, 2016, entitled "TRANSMISSION SCHEME AND INTER-CELL INTERFERENCE MITIGATION FOR 5G SIB", the contents of which are herein incorporated by reference in their entirety.

FIELD

[0002] The present disclosure relates to wireless technology, and more specifically to techniques for transmission of System Information Blocks (SIBs) and associated intercell interference mitigation.

BACKGROUND

[0003] Mobile communication has evolved significantly from early voice systems to today's highly sophisticated integrated communication platform. The next generation wireless communication system, 5G (Fifth Generation), will provide access to information and sharing of data anywhere at any time by various users and applications. 5G is expected to be a unified network/system that can meet vastly different and sometimes conflicting performance dimensions and services. These diverse multi-dimensional requirements are driven by different services and applications. In general, 5G will evolve based on 3GPP (Third Generation Partnership Project) LTE-Adv (Long Term Evolution-Advanced) with additional potential new Radio Access Technologies (RATs) to enrich peoples' lives with better, simple and seamless wireless connectivity solutions. 5G will enable everything to be connected by wireless and deliver fast, rich content and services.

[0004] For mid-band (carrier frequency between 6GHz and 30GHz) and high-band (carrier frequency beyond 30GHz), beamforming is one significant technology to improve the signal quality and reduce the inter user interference by directing narrow beams toward target users. For mid and high-band systems, the path loss caused by weather (like rain or fog) or objects can block and severely deteriorate the signal strength and damage the performance of the communications. Beamforming gain can compensate for the severe path loss, and thereby improve coverage range.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0005] **FIG. 1** is a block diagram illustrating an example user equipment (UE) useable in connection with various aspects described herein.
- [0006] **FIG. 2** is a flow diagram illustrating an example method that facilitates generation of a fifth generation (5G) System Information Block (xSIB), according to various aspects described herein.
- [0007] **FIG. 3** is a diagram illustrating an example of transmit (Tx) beam sweeping when the xSIB occupies the full system bandwidth according to various aspects described herein.
- [0008] **FIG. 4** is a diagram illustrating examples of Tx beam sweeping for xSIB occupying partial system bandwidth via either localized or distributed resource allocation, according to various aspects described herein.
- [0009] **FIG. 5** is a diagram illustrating examples of Demodulation Reference Signal (DM-RS) pattern for single port transmission when xSIB occupies 8 Resource Elements (REs), according to various aspects described herein.
- [0010] **FIG. 6** is a diagram illustrating examples of DM-RS pattern for single port transmission when xSIB occupies 12 REs, according to various aspects described herein.
- [0011] **FIG. 7** is a diagram illustrating an example DM-RS pattern for xSIB for two Antenna Ports (APs) when xSIB occupies 12 REs, according to various aspects described herein.
- [0012] **FIG. 8** is a diagram illustrating an example of a 1:1 Tx beam mapping between a 5G Physical Broadcast Channel (xPBCH) and xSIB transmission according to various aspects described herein.
- [0013] **FIG. 9** is a block diagram illustrating a system that facilitates generation of a fifth generation (5G) System Information Block (xSIB) by a base station for transmission to one or more User Equipments (UEs), according to various aspects described herein.
- [0014] **FIG. 10** is a block diagram illustrating a system that facilitates reception of a xSIB by a UE, according to various aspects described herein.
- [0015] **FIG. 11** is a flow diagram illustrating an example method that facilitates transmission of a xSIB according to various aspects described herein.
- [0016] **FIG. 12** is a flow diagram illustrating an example method that facilitates reception of a xSIB according to various aspects described herein.

DETAILED DESCRIPTION

[0017] The present disclosure will now be described with reference to the attached drawing figures, wherein like reference numerals are used to refer to like elements throughout, and wherein the illustrated structures and devices are not necessarily drawn to scale. As utilized herein, terms “component,” “system,” “interface,” and the like are intended to refer to a computer-related entity, hardware, software (e.g., in execution), and/or firmware. For example, a component can be a processor (e.g., a microprocessor, a controller, or other processing device), a process running on a processor, a controller, an object, an executable, a program, a storage device, a computer, a tablet PC and/or a user equipment (e.g., mobile phone, etc.) with a processing device. By way of illustration, an application running on a server and the server can also be a component. One or more components can reside within a process, and a component can be localized on one computer and/or distributed between two or more computers. A set of elements or a set of other components can be described herein, in which the term “set” can be interpreted as “one or more.”

[0018] Further, these components can execute from various computer readable storage media having various data structures stored thereon such as with a module, for example. The components can communicate via local and/or remote processes such as in accordance with a signal having one or more data packets (e.g., data from one component interacting with another component in a local system, distributed system, and/or across a network, such as, the Internet, a local area network, a wide area network, or similar network with other systems via the signal).

[0019] As another example, a component can be an apparatus with specific functionality provided by mechanical parts operated by electric or electronic circuitry, in which the electric or electronic circuitry can be operated by a software application or a firmware application executed by one or more processors. The one or more processors can be internal or external to the apparatus and can execute at least a part of the software or firmware application. As yet another example, a component can be an apparatus that provides specific functionality through electronic components without mechanical parts; the electronic components can include one or more processors therein to execute software and/or firmware that confer(s), at least in part, the functionality of the electronic components.

[0020] Use of the word exemplary is intended to present concepts in a concrete fashion. As used in this application, the term “or” is intended to mean an inclusive “or” rather than an exclusive “or”. That is, unless specified otherwise, or clear from context, “X employs A or B” is intended to mean any of the natural inclusive permutations. That is, if X employs A; X employs B; or X employs both A and B, then “X employs A or B” is satisfied under any of the foregoing instances. In addition, the articles “a” and “an” as used in this application and the appended claims should generally be construed to mean “one or more” unless specified otherwise or clear from context to be directed to a singular form. Furthermore, to the extent that the terms “including”, “includes”, “having”, “has”, “with”, or variants thereof are used in either the detailed description and the claims, such terms are intended to be inclusive in a manner similar to the term “comprising.”

[0021] As used herein, the term “circuitry” may refer to, be part of, or include an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group), and/or memory (shared, dedicated, or group) that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable hardware components that provide the described functionality. In some embodiments, the circuitry may be implemented in, or functions associated with the circuitry may be implemented by, one or more software or firmware modules. In some embodiments, circuitry may include logic, at least partially operable in hardware.

[0022] Embodiments described herein may be implemented into a system using any suitably configured hardware and/or software. **FIG. 1** illustrates, for one embodiment, example components of a User Equipment (UE) device 100. In some embodiments, the UE device 100 may include application circuitry 102, baseband circuitry 104, Radio Frequency (RF) circuitry 106, front-end module (FEM) circuitry 108 and one or more antennas 110, coupled together at least as shown.

[0023] The application circuitry 102 may include one or more application processors. For example, the application circuitry 102 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The processor(s) may include any combination of general-purpose processors and dedicated processors (e.g., graphics processors, application processors, etc.). The processors may be coupled with and/or may include memory/storage and may be configured to execute instructions stored in the memory/storage to enable various applications and/or operating systems to run on the system.

[0024] The baseband circuitry 104 may include circuitry such as, but not limited to, one or more single-core or multi-core processors. The baseband circuitry 104 may include one or more baseband processors and/or control logic to process baseband signals received from a receive signal path of the RF circuitry 106 and to generate baseband signals for a transmit signal path of the RF circuitry 106. Baseband processing circuitry 104 may interface with the application circuitry 102 for generation and processing of the baseband signals and for controlling operations of the RF circuitry 106. For example, in some embodiments, the baseband circuitry 104 may include a second generation (2G) baseband processor 104a, third generation (3G) baseband processor 104b, fourth generation (4G) baseband processor 104c, and/or other baseband processor(s) 104d for other existing generations, generations in development or to be developed in the future (e.g., fifth generation (5G), 6G, etc.). The baseband circuitry 104 (e.g., one or more of baseband processors 104a-d) may handle various radio control functions that enable communication with one or more radio networks via the RF circuitry 106. The radio control functions may include, but are not limited to, signal modulation/demodulation, encoding/decoding, radio frequency shifting, etc. In some embodiments, modulation/demodulation circuitry of the baseband circuitry 104 may include Fast-Fourier Transform (FFT), precoding, and/or constellation mapping/demapping functionality. In some embodiments, encoding/decoding circuitry of the baseband circuitry 104 may include convolution, tail-biting convolution, turbo, Viterbi, and/or Low Density Parity Check (LDPC) encoder/decoder functionality. Embodiments of modulation/demodulation and encoder/decoder functionality are not limited to these examples and may include other suitable functionality in other embodiments.

[0025] In some embodiments, the baseband circuitry 104 may include elements of a protocol stack such as, for example, elements of an evolved universal terrestrial radio access network (EUTRAN) protocol including, for example, physical (PHY), media access control (MAC), radio link control (RLC), packet data convergence protocol (PDCP), and/or radio resource control (RRC) elements. A central processing unit (CPU) 104e of the baseband circuitry 104 may be configured to run elements of the protocol stack for signaling of the PHY, MAC, RLC, PDCP and/or RRC layers. In some embodiments, the baseband circuitry may include one or more audio digital signal processor(s) (DSP) 104f. The audio DSP(s) 104f may include elements for compression/decompression and echo cancellation and may include other suitable

processing elements in other embodiments. Components of the baseband circuitry may be suitably combined in a single chip, a single chipset, or disposed on a same circuit board in some embodiments. In some embodiments, some or all of the constituent components of the baseband circuitry 104 and the application circuitry 102 may be implemented together such as, for example, on a system on a chip (SOC).

[0026] In some embodiments, the baseband circuitry 104 may provide for communication compatible with one or more radio technologies. For example, in some embodiments, the baseband circuitry 104 may support communication with an evolved universal terrestrial radio access network (EUTRAN) and/or other wireless metropolitan area networks (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN). Embodiments in which the baseband circuitry 104 is configured to support radio communications of more than one wireless protocol may be referred to as multi-mode baseband circuitry.

[0027] RF circuitry 106 may enable communication with wireless networks using modulated electromagnetic radiation through a non-solid medium. In various embodiments, the RF circuitry 106 may include switches, filters, amplifiers, etc. to facilitate the communication with the wireless network. RF circuitry 106 may include a receive signal path which may include circuitry to down-convert RF signals received from the FEM circuitry 108 and provide baseband signals to the baseband circuitry 104. RF circuitry 106 may also include a transmit signal path which may include circuitry to up-convert baseband signals provided by the baseband circuitry 104 and provide RF output signals to the FEM circuitry 108 for transmission.

[0028] In some embodiments, the RF circuitry 106 may include a receive signal path and a transmit signal path. The receive signal path of the RF circuitry 106 may include mixer circuitry 106a, amplifier circuitry 106b and filter circuitry 106c. The transmit signal path of the RF circuitry 106 may include filter circuitry 106c and mixer circuitry 106a. RF circuitry 106 may also include synthesizer circuitry 106d for synthesizing a frequency for use by the mixer circuitry 106a of the receive signal path and the transmit signal path. In some embodiments, the mixer circuitry 106a of the receive signal path may be configured to down-convert RF signals received from the FEM circuitry 108 based on the synthesized frequency provided by synthesizer circuitry 106d. The amplifier circuitry 106b may be configured to amplify the down-converted signals and the filter circuitry 106c may be a low-pass filter (LPF) or band-pass filter (BPF) configured to remove unwanted signals from the down-converted signals to generate output baseband

signals. Output baseband signals may be provided to the baseband circuitry 104 for further processing. In some embodiments, the output baseband signals may be zero-frequency baseband signals, although this is not a requirement. In some embodiments, mixer circuitry 106a of the receive signal path may comprise passive mixers, although the scope of the embodiments is not limited in this respect.

[0029] In some embodiments, the mixer circuitry 106a of the transmit signal path may be configured to up-convert input baseband signals based on the synthesized frequency provided by the synthesizer circuitry 106d to generate RF output signals for the FEM circuitry 108. The baseband signals may be provided by the baseband circuitry 104 and may be filtered by filter circuitry 106c. The filter circuitry 106c may include a low-pass filter (LPF), although the scope of the embodiments is not limited in this respect.

[0030] In some embodiments, the mixer circuitry 106a of the receive signal path and the mixer circuitry 106a of the transmit signal path may include two or more mixers and may be arranged for quadrature downconversion and/or upconversion respectively. In some embodiments, the mixer circuitry 106a of the receive signal path and the mixer circuitry 106a of the transmit signal path may include two or more mixers and may be arranged for image rejection (e.g., Hartley image rejection). In some embodiments, the mixer circuitry 106a of the receive signal path and the mixer circuitry 106a may be arranged for direct downconversion and/or direct upconversion, respectively. In some embodiments, the mixer circuitry 106a of the receive signal path and the mixer circuitry 106a of the transmit signal path may be configured for super-heterodyne operation.

[0031] In some embodiments, the output baseband signals and the input baseband signals may be analog baseband signals, although the scope of the embodiments is not limited in this respect. In some alternate embodiments, the output baseband signals and the input baseband signals may be digital baseband signals. In these alternate embodiments, the RF circuitry 106 may include analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry and the baseband circuitry 104 may include a digital baseband interface to communicate with the RF circuitry 106.

[0032] In some dual-mode embodiments, a separate radio IC circuitry may be provided for processing signals for each spectrum, although the scope of the embodiments is not limited in this respect.

[0033] In some embodiments, the synthesizer circuitry 106d may be a fractional-N synthesizer or a fractional N/N+1 synthesizer, although the scope of the embodiments is

not limited in this respect as other types of frequency synthesizers may be suitable. For example, synthesizer circuitry 106d may be a delta-sigma synthesizer, a frequency multiplier, or a synthesizer comprising a phase-locked loop with a frequency divider.

[0034] The synthesizer circuitry 106d may be configured to synthesize an output frequency for use by the mixer circuitry 106a of the RF circuitry 106 based on a frequency input and a divider control input. In some embodiments, the synthesizer circuitry 106d may be a fractional $N/N+1$ synthesizer.

[0035] In some embodiments, frequency input may be provided by a voltage controlled oscillator (VCO), although that is not a requirement. Divider control input may be provided by either the baseband circuitry 104 or the applications processor 102 depending on the desired output frequency. In some embodiments, a divider control input (e.g., N) may be determined from a look-up table based on a channel indicated by the applications processor 102.

[0036] Synthesizer circuitry 106d of the RF circuitry 106 may include a divider, a delay-locked loop (DLL), a multiplexer and a phase accumulator. In some embodiments, the divider may be a dual modulus divider (DMD) and the phase accumulator may be a digital phase accumulator (DPA). In some embodiments, the DMD may be configured to divide the input signal by either N or $N+1$ (e.g., based on a carry out) to provide a fractional division ratio. In some example embodiments, the DLL may include a set of cascaded, tunable, delay elements, a phase detector, a charge pump and a D-type flip-flop. In these embodiments, the delay elements may be configured to break a VCO period up into N_d equal packets of phase, where N_d is the number of delay elements in the delay line. In this way, the DLL provides negative feedback to help ensure that the total delay through the delay line is one VCO cycle.

[0037] In some embodiments, synthesizer circuitry 106d may be configured to generate a carrier frequency as the output frequency, while in other embodiments, the output frequency may be a multiple of the carrier frequency (e.g., twice the carrier frequency, four times the carrier frequency) and used in conjunction with quadrature generator and divider circuitry to generate multiple signals at the carrier frequency with multiple different phases with respect to each other. In some embodiments, the output frequency may be a LO frequency (f_{LO}). In some embodiments, the RF circuitry 106 may include an IQ/polar converter.

[0038] FEM circuitry 108 may include a receive signal path which may include circuitry configured to operate on RF signals received from one or more antennas 110,

amplify the received signals and provide the amplified versions of the received signals to the RF circuitry 106 for further processing. FEM circuitry 108 may also include a transmit signal path which may include circuitry configured to amplify signals for transmission provided by the RF circuitry 106 for transmission by one or more of the one or more antennas 110.

[0039] In some embodiments, the FEM circuitry 108 may include a TX/RX switch to switch between transmit mode and receive mode operation. The FEM circuitry may include a receive signal path and a transmit signal path. The receive signal path of the FEM circuitry may include a low-noise amplifier (LNA) to amplify received RF signals and provide the amplified received RF signals as an output (e.g., to the RF circuitry 106). The transmit signal path of the FEM circuitry 108 may include a power amplifier (PA) to amplify input RF signals (e.g., provided by RF circuitry 106), and one or more filters to generate RF signals for subsequent transmission (e.g., by one or more of the one or more antennas 110).

[0040] In some embodiments, the UE device 100 may include additional elements such as, for example, memory/storage, display, camera, sensor, and/or input/output (I/O) interface.

[0041] Additionally, although the above example discussion of device 100 is in the context of a UE device, in various aspects, a similar device can be employed in connection with a base station (BS) such as an Evolved NodeB (eNB).

[0042] Although beamforming gain can compensate for the greater pathloss involved in transmitting at mid-band and/or high-band frequencies, the directional nature of beamformed transmissions can introduce additional complications. For example, in situations where Tx beam sweeping is applied for the xPDCCH (5G (fifth generation) Physical Downlink Control Channel) with common search space, repeated transmission may be appropriate, which could increase system overhead and thereby reduce spectrum efficiency. To reduce system overhead, xPDCCH-less operation can be considered for the 5G system information block (xSIB). In such situations, the scheduling of xSIB transmission can be indicated in the 5G master information block (xMIB).

[0043] If multiple cells transmit the xSIB on the same time and frequency resource, severe inter-cell interference can be observed. To reduce the inter-cell interference and improve the decoding performance for xSIB transmission, mechanisms to coordinate

the transmission of xSIB among multiple cells such as those described herein can be employed.

[0044] Various embodiments can employ techniques discussed herein related to xSIB design details for 5G systems. In various aspects, these techniques can comprise various details associated with transmission scheme(s) for xSIB, and/or mechanism(s) that can reduce the inter-cell interference for xSIB transmission.

[0045] In various aspects, the payload size for the transmission of xSIB can be different for different use cases and deployment scenarios. Thus, information regarding the payload size can be made available at the UE side to ensure proper demodulation and decoding.

[0046] In some aspects, N possible payload sizes (e.g., N = 4, or greater or lesser numbers) for xSIB transmission. A field can be included in the xMIB (5G Master Information Block) that can be used to indicate which payload size is used for xSIB transmission. Table 1, below, shows an example field that can be included in a xMIB to indicate one of 4 distinct payload sizes for a xSIB:

Table 1: xSIB payload size

Bit field in xMIB	xSIB payload size
'00'	Transport block size #0
'01'	Transport block size #1
'10'	Transport block size #2
'11'	Transport block size #3

[0047] Additionally, the xSIB transmission periodicity can also be indicated in the xMIB. For example, one field comprising one or more bits can be used to indicate the xSIB transmission periodicity (e.g., bit 0 can indicate that xSIB transmission periodicity is 80ms, while bit 1 indicates that xSIB transmission periodicity is 160ms, etc.).

[0048] Alternatively, xSIB transmission periodicity can have a 1:1 association with xSIB payload size. For a small payload size, a shorter transmission periodicity can be defined, while for a large payload size, a longer transmission periodicity can be defined. This option can help to reduce the signaling overhead in the xMIB.

[0049] In some embodiments, a xSIB resource map can be determined by the payload size. For example, for a large payload size, one xSIB block can occupy a full system bandwidth (e.g., as shown in FIG. 3, discussed below), while for small payload

size, one xSIB can occupy a partial system bandwidth (e.g., as shown in FIG. 4, discussed below).

[0050] Referring to **FIG. 2**, illustrated is an example method 200 for the generation of a xSIB, according to various aspects described herein. A detailed design for the xSIB can be as described below.

[0051] At 210, coding can be applied to the xSIB information bits (e.g., which can comprise X bits, where X is any positive integer, for example, one of the values that can be indicated via a corresponding field in the xMIB). In one example, a tail-biting convolutional coder (TBCC) can be applied to the xSIB. In aspects, a CRC (cyclic redundancy check) can be appended on the xSIB information bits prior to the encoding. In other examples, turbo code or LDPC (low density parity check) can be applied to the xSIB information bits instead of the TBCC.

[0052] At 220, after coding, a cell specific scrambling can be used to further randomize the interference. In aspects, the scrambling seed can be defined as a function of one or more of a physical cell ID, a subframe index, a slot index, or a symbol index for the transmission of xSIB. In one example, the scrambling seed can be given by equation 1:

$$C_{init} = 2^{10} \cdot (7 \cdot (n_s + 1) + l + 1) \cdot (2 \cdot N_{ID}^{cell} + 1) + 2 \cdot N_{ID}^{cell} + 1 \quad (1),$$

where n_s is the slot index, l is the OFDM (orthogonal frequency division multiplexing) symbol index, and N_{ID}^{cell} is the physical cell ID.

[0053] At 230, a modulation type having a low modulation order (e.g., BPSK (Binary Phase Shift Keying) or QPSK (Quadrature Phase Shift Keying), etc.) can be used for the modulation to ensure robust performance.

[0054] At 240, the modulated symbols generated at 230 can be mapped to allocated resources, where the resource mapping mechanism can be as described below.

[0055] To allow Tx (transmit) beam sweeping for the xSIB transmission, one xSIB transmission can span 1 or more OFDM symbols. Depending on the payload size, the xSIB transmission can occupy a partial or a full system bandwidth. For the former case, the xSIB payload size can be small.

[0056] In some embodiments, the xSIB transmission occupies a full system bandwidth. Additionally, different Tx beams can be applied on each OFDM symbol to ensure good cell coverage. Referring to **FIG. 3**, illustrated is one example of Tx beam

sweeping when the xSIB occupies the full system bandwidth according to various aspects described herein. Note that in the example of FIG. 3, the same xSIB information bits are transmitted in each OFDM symbol, but by different Tx beams.

[0057] In embodiments wherein xSIB occupies partial system bandwidth, either a localized or a distributed transmission scheme can be employed. The number of xSIB block in one symbol can be determined by the number of BRS (beam reference signal) antenna ports. The Tx beam for each xSIB block can be one-to-one mapped to the Tx beam applied to the BRS. Referring to **FIG. 4**, illustrated are examples of Tx beam sweeping for xSIB occupying partial system bandwidth via either localized or distributed resource allocation, according to various aspects described herein. The example shown in FIG. 4 shows 4 Tx beams per symbol, for a total of 56 beams that can be applied to the BRS in one subframe. The 56 Tx beams sweeping can be also applied to the xSIB subframe. In various aspects, the Tx beam mapping rule between xSIB and BRS can be pre-defined by the specification, such that the UE can select the best xSIB block(s) to decode. The best xSIB block(s) can be the one(s) from which the highest BRS-RP is obtained from the associated Tx beam.

[0058] Depending on the number of resource elements (REs) allocated for each xSIB block and the number of APs (Antenna Ports) for xSIB transmission, different options for the DM-RS (Demodulation Reference Signal) pattern can be provided as follows.

[0059] Referring to **FIG. 5**, illustrated are examples of DM-RS pattern for single port transmission when xSIB occupies 8 REs, according to various aspects described herein. Referring to **FIG. 6**, illustrated are examples of DM-RS pattern for single port transmission when xSIB occupies 12 REs, according to various aspects described herein. Note that similar pattern can be defined for two port xSIB transmission, as shown in **FIG. 7**, illustrating an example DM-RS pattern for xSIB for two APs when xSIB occupies 12 REs, according to various aspects described herein. In various aspects, the DM-RS for these two APs can be multiplexed in a Frequency-division multiplexing (FDM) or a Code Division Multiplexing (CDM) manner.

[0060] In the case of CDM multiplexing between two APs, an orthogonal cover code (OCC) can be applied on each AP, which can be defined as in Table 2, below:

Table 2: OCC for two APs

Antenna port p	$[w_p(0) \ w_p(1)]$
100	$[1 \ 1]$
101	$[1 \ -1]$

[0061] In embodiments wherein SFBC (space frequency block coding) is applied for xSIB transmission, two consecutive REs can be used for xSIB transmission.

[0062] In various aspects, to minimize power consumption by the UE, a 1:1 Tx beam mapping between synchronization signals/beam reference signal (BRS)/xPBCH and xSIB can be defined. In such aspects, a UE can listen to only one symbol for xSIB decoding. Referring to **FIG. 8**, illustrated is one example of a 1:1 Tx beam mapping between xPBCH and xSIB transmission according to various aspects described herein. In one example, if a UE decodes xPBCH successfully on symbol #3 in Tx beam group #1, it can decode xSIB on symbol #3 on the corresponding xSIB subframe using the same Rx beam(s).

[0063] Various aspects described herein can also facilitate mitigation of inter-cell interference associated with xSIB transmission. One or more of the following techniques can be employed for inter-cell interference mitigation for xSIB transmission(s).

[0064] In some aspects, different cells can transmit xSIB in different frames and subframes (SFs). In one example, cell $\#(3k)$ can transmit xSIB in SF#47, cell $\#(3k+1)$ can transmit xSIB in SF#48 and cell $\#(3k+2)$ can transmit xSIB in SF#49, for $k = 0, 1, \dots, \left\lfloor \frac{N_{cell}^{ID}}{3} \right\rfloor - 1$. In other aspects, more or less than 3 groups can be employed in a similar manner.

[0065] In other aspects, different cells can transmit xSIB in same subframe, but in different frequency resources. This technique can be appropriate when the xSIB payload size is small. In one example, the system bandwidth may be divided into N blocks (e.g., $N=3$, or greater or lesser numbers), which can be distributed or localized in the frequency domain. Depending on the physical cell ID, different cells can transmit xSIB in different blocks, which can create a reuse- N transmission pattern.

[0066] In some aspects, the frame and/or the subframe index used for the transmission of xSIB can be defined as a function of physical cell ID, such as $n_{SF} = f(N_{cell}^{ID})$.

[0067] In further aspects, a field in the xMIB can be used to indicate the frame and/or the subframe index used for the transmission of xSIB. A set of frames and/or subframes

used for the transmission of xSIB can be predefined in the specification. The bit field in the xMIB can be used to indicate which frame and/or subframe is used for xSIB transmission. Table 3, below, illustrates one example of bit field indication in the xMIB, with four example values provided (in various aspects, more or fewer can be provided). In the example, xSIB can be transmitted in one subframe in two frames, or 20ms. Note that other example can be straightforwardly extended from the example listed below.

Table 3. xSIB transmission timing

Bit field in xMIB	xSIB transmission frame and subframe
'00'	Frame #0, subframe 1
'01'	Frame#1, subframe 1
'10'	Frame #0, subframe 26
'11'	Frame #1, subframe 26

[0068] Referring to **FIG. 9**, illustrated is a block diagram of a system 900 that facilitates generation of a fifth generation (5G) System Information Block (xSIB) by a base station for transmission to one or more User Equipments (UEs), according to various aspects described herein. System 900 can include one or more processors 910 (e.g., one or more baseband processors, such as one or more of the baseband processors discussed in connection with FIG. 1), transceiver circuitry 920 (e.g., which can comprise one or more of transmitter circuitry (e.g., associated with one or more transmit chains) or receiver circuitry (e.g., associated with one or more receive chains), wherein the transmitter circuitry and receiver circuitry can employ common circuit elements, distinct circuit elements, or a combination thereof), and memory 930 (which can comprise any of a variety of storage mediums and can store instructions and/or data associated with one or more of processor(s) 910 or transceiver circuitry 920). In various aspects, system 900 can be included within an Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Node B (Evolved Node B, eNodeB, or eNB) or other base station in a wireless communications network. In some aspects, the processor(s) 910, transceiver circuitry 920, and the memory 930 can be included in a single device, while in other aspects, they can be included in different devices, such as part of a distributed architecture. As described in greater detail below, system 900 can facilitate generation of a xSIB for subsequent transmission via a plurality of distinct transmit (Tx) beams to one or more UEs.

[0069] In various aspects, processor(s) 910 can generate a 5G Master Information Block (xMIB) and can output the xMIB to transceiver circuitry 220 for transmission (e.g., via a 5G Physical Broadcast Channel (xPBCH), etc.) to one or more UEs. Processor(s) 910 can generate the xMIB to indicate one or more parameters of a xSIB. For example, the xMIB can indicate a size of the xSIB, such as via a payload size of the xSIB, a transmission duration of the xSIB, etc. As another example, the xMIB can indicate one or more parameters associated with the timing of transmission(s) of the xSIB, such as a transmission periodicity of the xSIB, frame(s) and/or subframe(s) during which the xSIB will be transmitted (which can be selected to minimize inter-cell interference by avoiding frame(s) and/or subframe(s) indicated for neighboring cells), etc. In other examples, the transmission periodicity can be based on the payload size of the xSIB (e.g., via predefined associations in the specification, etc.) indicated by the xMIB.

[0070] Processor(s) 910 can generate a xSIB, as described in greater detail herein. Processor(s) 910 can generate a set of bits, which can comprise data for the xSIB, and can apply coding (e.g., CRC followed by TBCC, turbo code, LDPC, etc.) to the generated set of bits to obtain a coded set of xSIB bits. In aspects, the type of coding applied can depend on the payload size of the xSIB.

[0071] Processor(s) 910 can scramble the coded set of xSIB bits to obtain a scrambled set of xSIB bits, which can be based on a scrambling sequence initialized by a scrambling seed that can depend on one or more of the physical cell ID, the subframe index, the slot index, or the OFDM symbol index.

[0072] Processor(s) 910 can modulate the scrambled set of xSIB bits based on a modulation type to obtain a modulated set of xSIB symbols. The modulation type can be a type having a low modulation order (e.g., BPSK, QPSK, etc.), which can ensure robust transmission of the xSIB.

[0073] Processor(s) 910 can map the modulated set of xSIB symbols to a set of frequency domain resources, which can be associated with a physical xSIB channel (e.g., a dedicated channel for xSIB, a 5G physical downlink shared channel (xPDSCH), etc.). The frequency domain resources can be selected based at least in part on the payload size of the xSIB, and can vary based on the embodiment. For example, for a large xSIB block, the frequency domain resources can comprise a full system bandwidth. As another example, for a small xSIB block, the frequency domain resources can comprise a partial system bandwidth (e.g., 1/N of a full system bandwidth, for example, for N=3, etc.), and other portions of the system bandwidth can

be employed by neighboring cells to mitigate inter-cell interference. In some examples, when the xSIB block is smaller than either a full system bandwidth or a fraction of the system bandwidth employed by the cell for mitigation of inter-cell interference, multiple copies of the xSIB block can be allocated across that bandwidth, each of which can be associated with a distinct BRS antenna port (AP).

[0074] Processor(s) 910 can output the physical xSIB channel to transceiver circuitry 920 for transmission during a selected subframe. Depending on the type of signal or message generated, outputting for transmission (e.g., by processor(s) 910, processor(s) 1010, etc.) can comprise one or more acts such as those discussed above in connection with the xSIB, for example: generating a set of associated bits that indicate the content of the signal or message, coding (e.g., which can include adding a cyclic redundancy check (CRC) and/or coding via one or more of turbo code, low density parity-check (LDPC) code, tail-biting convolution code (TBCC), etc.), scrambling (e.g., based on a scrambling seed), modulating (e.g., via one of binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), or some form of quadrature amplitude modulation (QAM), etc.), and/or resource mapping (e.g., to a scheduled set of resources, to a set of time and frequency resources granted for uplink transmission, etc.).

[0075] Processor(s) 910 can output the physical xSIB channel for transmission by transceiver circuitry 920 via one or more distinct Tx beams for each of a plurality of OFDM symbols of the subframe selected for xSIB transmission. For larger xSIB blocks, or in some frequency-based inter-cell interference mitigation scenarios involving smaller xSIB blocks, a single Tx beam can be employed for each OFDM symbol, transmitting the xSIB via either the full system bandwidth (for larger xSIB blocks) or an entire portion of the system bandwidth employed by the cell (for some smaller xSIB blocks with inter-cell interference mitigation based on distinct frequency resources). For other aspects involving smaller xSIB blocks, a plurality of distinct Tx beams can be employed for each OFDM symbol, and frequency domain resources can be assigned between those Tx beams based on either a localized or distributed scheme, such as shown in the examples of FIG. 4. In aspects, the one or more distinct Tx beams selected for transmission of the xSIB block for each OFDM symbol can be based on a predefined association or mapping between the xSIB and Tx beams employed for transmission of one or more of synchronization signals, beam reference signal (BRS), xPBCH, etc., which can facilitate xSIB block selection by UEs.

[0076] Additionally, the physical xSIB channel can be transmitted via a xSIB block that comprises a set of DM-RS. The set of DM-RS can be arranged based on a predetermined pattern, which can depend on the number of REs for each xSIB block and/or the number of APs for xSIB transmission. Example patterns for specific values of REs and APs are provided in FIGS. 5-7. For multiple APs, multiplexing can be based on frequency domain multiplexing (FDM) or code division multiplexing (CDM). For SFBC applied in connection with xSIB transmission, consecutive pairs of REs can be used for xSIB transmission.

[0077] In some aspects, xSIB transmission can be based on one or more techniques to mitigate inter-cell interference. In various embodiments, distinct time domain resources and/or frequency domain resources can be employed by various cells to mitigate interference.

[0078] In various aspects associated with interference mitigation based on distinct time domain resources, cells can transmit xSIB during frame(s) and/or subframe(s) that can depend on the physical cell ID. As one example, cells can be partitioned into N groups (e.g., $N=3$, etc.) based on physical cell ID, with each group associated with a distinct frame and/or subframe for xSIB transmission. For example, cells can be assigned to distinct groups based on the remainder after dividing the physical cell ID by N, or based on some other function of the physical cell ID. In some aspects, as discussed herein, the frame(s) and/or subframe(s) can be indicated via a field included in the xMIB.

[0079] In various aspects in connection with interference mitigation based on distinct frequency domain resources, the full system bandwidth can be divided into N (e.g., 3, etc.) distinct portions, and cells can be partitioned into N groups, with each group associated with a distinct one of the N portions. As an example, cells can be assigned to a distinct portion based on the remainder after dividing the physical cell ID by N, or based on some other function of the physical cell ID.

[0080] Referring to **FIG. 10**, illustrated is a block diagram of a system 1000 that facilitates reception of a xSIB by a UE, according to various aspects described herein. System 1000 can include one or more processors 1010 (e.g., one or more baseband processors such as one or more of the baseband processors discussed in connection with FIG. 1), transceiver circuitry 1020 (e.g., comprising one or more of transmitter circuitry or receiver circuitry, which can employ common circuit elements, distinct circuit elements, or a combination thereof), and a memory 1030 (which can comprise any of a

variety of storage mediums and can store instructions and/or data associated with one or more of processor(s) 1010 or transceiver circuitry 1020). In various aspects, system 1000 can be included within a user equipment (UE). As described in greater detail below, system 1000 can facilitate determination of parameters of a xSIB and reception of the xSIB based on the determined parameters.

[0081] Transceiver circuitry 1020 can receive, and processor(s) 1010 can process, a xMIB from an eNB. Depending on the type of received signal or message, processing (e.g., by processor 210, processor 310, etc.) can comprise one or more of: identifying physical resources associated with the signal/message, detecting the signal/message, resource element group deinterleaving, demodulation, descrambling, and/or decoding.

[0082] The xMIB processed by processor(s) 1010 can indicate one or more parameters of a xSIB that can be determined by processor(s) 1010 from the xMIB. These parameters can comprise a xSIB payload size, and/or parameters associated with transmission timing of the xSIB, such as a transmission periodicity, specific frame(s) and/or subframe(s) for xSIB transmission, etc. In some aspects, the transmission periodicity can be implicitly indicated via the xSIB payload size and a predefined association between xSIB payload sizes and transmission periodicities.

[0083] Transceiver circuitry 1020 can receive, and processor(s) 1010 can process, a physical xSIB channel from an eNB during a given subframe, over a selected Tx beam. The processor(s) 1010 can select the Tx beam as a best Tx beam as determined based on beam reference signal received power (B-RSRP) measurements of one or more Tx beams from the eNB. Additionally, in some aspects, a relationship between xSIB and xPBCH can be predefined (e.g., as in the example of FIG. 8, etc.), such that the OFDM symbol of the selected Tx beam can be readily determined by processor(s) 1010.

[0084] In various aspects related to inter-cell interference mitigation, the frequency domain resources associated with the xSIB and/or the frame(s) and/or subframe(s) for xSIB transmission can vary between cells (e.g., based on the physical cell ID) as described herein. In such aspects, processor(s) 1010 can select the frequency domain resources and/or the appropriate frame(s) and/or subframe(s) based on the type of interference mitigation employed.

[0085] Referring to **FIG. 11**, illustrated is a flow diagram of a method 1100 that facilitates transmission of a xSIB according to various aspects described herein. In some aspects, method 1100 can be performed at an eNB. In other aspects, a machine

readable medium can store instructions associated with method 1100 that, when executed, can cause an eNB to perform the acts of method 1100.

[0086] At 1110, a xSIB and associated parameters can be determined, such as payload size, transmission periodicity, etc.

[0087] At 1120, a xMIB can be transmitted via a xPBCH that indicates one or more of the parameters of the xSIB.

[0088] At 1130, based on the parameters, a physical xSIB channel can be generated for one or more OFDM symbols of a plurality of OFDM symbols of a subframe.

[0089] At 1140, the physical xSIB channel can be transmitted via a distinct set of one or more Tx beams during each OFDM symbol of the plurality of OFDM symbols of the subframe.

[0090] Referring to **FIG. 12**, illustrated is a flow diagram of a method 1200 that facilitates reception of a xSIB by a UE according to various aspects described herein. In some aspects, method 1200 can be performed at a UE. In other aspects, a machine readable medium can store instructions associated with method 1200 that, when executed, can cause a UE to perform the acts of method 1200.

[0091] At 1210, a xMIB can be received that indicates one or more parameters of a xSIB (e.g., payload size, transmission periodicity, frame(s) and/or subframe(s) for transmission of the xSIB, etc.).

[0092] At 1220, the one or more parameters can be determined from the xMIB.

[0093] At 1230, a physical xSIB channel can be received based on the determined parameters. The physical xSIB channel received can be transmitted via a Tx beam selected based on having a highest B-RSRP among Tx beams transmitting the physical xSIB channel.

[0094] Examples herein can include subject matter such as a method, means for performing acts or blocks of the method, at least one machine-readable medium including executable instructions that, when performed by a machine (e.g., a processor with memory, an application-specific integrated circuit (ASIC), a field programmable gate array (FPGA), or the like) cause the machine to perform acts of the method or of an apparatus or system for concurrent communication using multiple communication technologies according to embodiments and examples described.

[0095] Example 1 is an apparatus configured to be employed within an Evolved NodeB (eNB), comprising a processor configured to: generate a set of bits for a fifth generation (5G) System Information Block (xSIB); apply coding to the set of bits for the

xSIB to generate a coded set of xSIB bits; scramble the coded set of xSIB bits to generate a scrambled set of xSIB bits; modulate the scrambled set of xSIB bits to generate a modulated set of xSIB symbols; map the modulated set of xSIB symbols to a set of frequency domain resources to generate a physical xSIB channel; and output the physical xSIB channel to transceiver circuitry for transmission by a plurality of transmit (Tx) beams during a subframe, wherein the physical xSIB channel is output for transmission via one or more distinct Tx beams of the plurality of Tx beams during one or more of a plurality of distinct orthogonal frequency division multiplexing (OFDM) symbols of the subframe.

[0096] Example 2 comprises the subject matter of any variation of example 1, wherein the processor is further configured to output a 5G Master Information Block (xMIB) that indicates one or more of a payload size of the xSIB or a transmission duration of the xSIB.

[0097] Example 3 comprises the subject matter of any variation of example 2, wherein the xMIB indicates a transmission periodicity of the xSIB.

[0098] Example 4 comprises the subject matter of any variation of example 2, wherein a periodicity of the xSIB is based at least in part on the payload size of the xSIB.

[0099] Example 5 comprises the subject matter of any variation of example 2, wherein the processor is further configured to select the set of frequency domain resources based at least in part on the payload size of the xSIB.

[00100] Example 6 comprises the subject matter of any variation of any of examples 1-5, wherein, for each of the plurality of distinct OFDM symbols, the one or more distinct Tx beams comprise a single distinct Tx beam for transmission of the physical xSIB channel via the entire set of frequency domain resources.

[00101] Example 7 comprises the subject matter of any variation of any of examples 1-5, wherein, for each of the plurality of distinct OFDM symbols, the one or more distinct Tx beams comprise two or more distinct Tx beams for transmission of the physical xSIB channel via a distinct subset of the set of frequency domain resources associated with that Tx beam of the two or more distinct Tx beams.

[00102] Example 8 comprises the subject matter of any variation of example 7, wherein, for each of the two or more distinct Tx beams for each OFDM symbol, the distinct subset of the set of frequency domain resources associated with that Tx beam comprises a localized subset of the system bandwidth.

[00103] Example 9 comprises the subject matter of any variation of example 7, wherein, for each of the two or more distinct Tx beams for each OFDM symbol, the distinct subset of the set of frequency domain resources associated with that Tx beam comprises a distributed subset of the system bandwidth.

[00104] Example 10 comprises the subject matter of any variation of any of examples 1-5, wherein the plurality of Tx beams is selected based on a predefined mapping between the xSIB and a set of Tx beams employed for transmission of one or more of synchronization signals, beam reference signals (BRSs) or a 5G physical broadcast channel (xPBCH).

[00105] Example 11 comprises the subject matter of any variation of any of examples 1-9, wherein the plurality of Tx beams is selected based on a predefined mapping between the xSIB and a set of Tx beams employed for transmission of one or more of synchronization signals, beam reference signals (BRSs) or a 5G physical broadcast channel (xPBCH).

[00106] Example 12 comprises the subject matter of any variation of example 1, wherein, for each of the plurality of distinct OFDM symbols, the one or more distinct Tx beams comprise a single distinct Tx beam for transmission of the physical xSIB channel via the entire set of frequency domain resources.

[00107] Example 13 comprises the subject matter of any variation of example 1, wherein, for each of the plurality of distinct OFDM symbols, the one or more distinct Tx beams comprise two or more distinct Tx beams for transmission of the physical xSIB channel via a distinct subset of the set of frequency domain resources associated with that Tx beam of the two or more distinct Tx beams.

[00108] Example 14 comprises the subject matter of any variation of example 13, wherein, for each of the two or more distinct Tx beams for each OFDM symbol, the distinct subset of the set of frequency domain resources associated with that Tx beam comprises a localized subset of the system bandwidth.

[00109] Example 15 comprises the subject matter of any variation of example 13, wherein, for each of the two or more distinct Tx beams for each OFDM symbol, the distinct subset of the set of frequency domain resources associated with that Tx beam comprises a distributed subset of the system bandwidth.

[00110] Example 16 comprises the subject matter of any variation of example 1, wherein the plurality of Tx beams is selected based on a predefined mapping between the xSIB and a set of Tx beams employed for transmission of one or more of

synchronization signals, beam reference signals (BRSs) or a 5G physical broadcast channel (xPBCH).

[00111] Example 17 is a machine readable medium comprising instructions that, when executed, cause an Evolved NodeB (eNB) to: determine a fifth generation (5G) System Information Block (xSIB); transmit, via a 5G Physical Broadcast Channel (xPBCH), a 5G Master Information Block (xMIB) that indicates one or more parameters of the xSIB, wherein the one or more parameters comprise a payload size of the xSIB; generate, for one or more orthogonal frequency division multiplexing (OFDM) symbols of a plurality of OFDM symbols of a subframe, a physical xSIB channel associated with that OFDM symbol, wherein each physical xSIB channel is generated based at least in part on the one or more parameters; and transmit, during each OFDM symbol of the plurality of OFDM symbols and via a common set of frequency domain resources, the physical xSIB channel associated with that symbol via a distinct transmit (Tx) beam of a plurality of Tx beams.

[00112] Example 18 comprises the subject matter of any variation of example 17, wherein the instructions, when executed, further cause the eNB to select the subframe or frame index based on a physical cell identity associated with the eNB.

[00113] Example 19 comprises the subject matter of any variation of example 18, wherein the instructions, when executed, further cause the eNB to select the subframe or frame index based on the remainder resulting from dividing the physical cell identity by n , wherein n is a number of distinct groups of cells for mitigation of inter-cell interference.

[00114] Example 20 comprises the subject matter of any variation of example 17, wherein the instructions, when executed, further cause the eNB to select the common set of frequency domain resources based on a physical cell identity associated with the eNB.

[00115] Example 21 comprises the subject matter of any variation of example 20, wherein the instructions, when executed, further cause the eNB to select the common set of frequency domain resources based on the remainder resulting from dividing the physical cell identity by n , wherein n is a number of distinct groups of cells for mitigation of inter-cell interference.

[00116] Example 22 comprises the subject matter of any variation of example 17, wherein the one or more parameters comprise the subframe used for the xSIB transmission.

[00117] Example 23 comprises the subject matter of any variation of any of examples 17-22, wherein the instructions, when executed, further cause the eNB to transmit each physical xSIB channel via a xSIB block that comprises a plurality of demodulation reference signals (DM-RS) arranged based on a predetermined pattern.

[00118] Example 24 comprises the subject matter of any variation of example 23, wherein the plurality of DM-RS comprise DM-RS for a pair of antenna ports (APs), wherein the DM-RS for the pair of APs are multiplexed via frequency-division multiplexing (FDM).

[00119] Example 25 comprises the subject matter of any variation of example 23, wherein the plurality of DM-RS comprise DM-RS for a pair of antenna ports (APs), wherein the DM-RS for the pair of APs are multiplexed via code-division multiplexing (CDM) based on a pair of orthogonal cover codes (OCCs).

[00120] Example 26 comprises the subject matter of any variation of any of examples 17-22, wherein the instructions, when executed, further cause the eNB to transmit each physical xSIB channel using Tx beams based on a predetermined Tx beam mapping between the xPBCH and the xSIB.

[00121] Example 27 comprises the subject matter of any variation of example 17, wherein the instructions, when executed, further cause the eNB to transmit each physical xSIB channel via a xSIB block that comprises a plurality of demodulation reference signals (DM-RS) arranged based on a predetermined pattern.

[00122] Example 28 comprises the subject matter of any variation of example 27, wherein the plurality of DM-RS comprise DM-RS for a pair of antenna ports (APs), wherein the DM-RS for the pair of APs are multiplexed via frequency-division multiplexing (FDM).

[00123] Example 29 comprises the subject matter of any variation of example 27, wherein the plurality of DM-RS comprise DM-RS for a pair of antenna ports (APs), wherein the DM-RS for the pair of APs are multiplexed via code-division multiplexing (CDM) based on a pair of orthogonal cover codes (OCCs).

[00124] Example 30 comprises the subject matter of any variation of example 17, wherein the instructions, when executed, further cause the eNB to transmit each physical xSIB channel using Tx beams based on a predetermined Tx beam mapping between the xPBCH and the xSIB.

[00125] Example 31 is an apparatus configured to be employed within a User Equipment (UE), comprising a processor configured to: process a fifth generation (5G)

Master Information Block (xMIB) received via transceiver circuitry; determine, based on the xMIB, one or more parameters of a 5G System Information Block (xSIB); and process a physical xSIB channel received from an Evolved NodeB (eNB) during a subframe by the transceiver circuitry, wherein the xSIB was transmitted by the eNB via a selected Tx beam over one or more given orthogonal frequency division multiplexing (OFDM) symbols of a plurality of OFDM symbols, wherein the given OFDM symbols are associated with the selected Tx beam.

[00126] Example 32 comprises the subject matter of any variation of example 31, wherein the one or more parameters comprise a payload size of the xSIB.

[00127] Example 33 comprises the subject matter of any variation of example 31, wherein the one or more parameters comprise a transmission periodicity of the xSIB.

[00128] Example 34 comprises the subject matter of any variation of any of examples 31-33, wherein the one or more parameters comprise the subframe used for the xSIB transmission.

[00129] Example 35 comprises the subject matter of any variation of any of examples 31-33, wherein the processor is further configured to measure a distinct beam reference signal received power (BRS-RP) associated with each Tx beam of a set of Tx beams comprising the selected Tx beam, wherein the selected Tx beam is selected based on the distinct BRS-RP associated with the selected Tx beam.

[00130] Example 36 comprises the subject matter of any variation of any of examples 31-33, wherein the processor is further configured to determine the subframe based on a physical cell identity of the eNB.

[00131] Example 37 comprises the subject matter of any variation of any of examples 31-33, wherein the xSIB is received via a set of frequency domain resources based on a physical cell identity of the eNB.

[00132] Example 38 comprises the subject matter of any variation of example 31, wherein the one or more parameters comprise the subframe used for the xSIB transmission.

[00133] Example 39 comprises the subject matter of any variation of example 31, wherein the processor is further configured to measure a distinct beam reference signal received power (BRS-RP) associated with each Tx beam of a set of Tx beams comprising the selected Tx beam, wherein the selected Tx beam is selected based on the distinct BRS-RP associated with the selected Tx beam.

[00134] Example 40 comprises the subject matter of any variation of example 31, wherein the processor is further configured to determine the subframe based on a physical cell identity of the eNB.

[00135] Example 41 comprises the subject matter of any variation of example 31, wherein the xSIB is received via a set of frequency domain resources based on a physical cell identity of the eNB.

[00136] Example 42 is an apparatus configured to be employed within an Evolved NodeB (eNB), comprising means for processing and means for communication. The means for processing is configured to determine a fifth generation (5G) System Information Block (xSIB). The means for communication is configured to transmit, via a 5G Physical Broadcast Channel (xPBCH), a 5G Master Information Block (xMIB) that indicates one or more parameters of the xSIB, wherein the one or more parameters comprise a payload size of the xSIB. The means for processing is further configured to generate, for one or more orthogonal frequency division multiplexing (OFDM) symbols of a plurality of OFDM symbols of a subframe, a physical xSIB channel associated with that OFDM symbol, wherein each physical xSIB channel is generated based at least in part on the one or more parameters. The means for communication is further configured to transmit, during each OFDM symbol of the plurality of OFDM symbols and via a common set of frequency domain resources, the physical xSIB channel associated with that symbol via a distinct transmit (Tx) beam of a plurality of Tx beams.

[00137] Example 43 comprises the subject matter of any variation of example 42, wherein the means for processing is further configured to select the subframe or frame index based on a physical cell identity associated with the eNB.

[00138] Example 44 comprises the subject matter of any variation of example 43, wherein the means for processing is further configured to select the subframe or frame index based on the remainder resulting from dividing the physical cell identity by n , wherein n is a number of distinct groups of cells for mitigation of inter-cell interference.

[00139] Example 45 comprises the subject matter of any variation of example 42, wherein means for processing is further configured to select the common set of frequency domain resources based on a physical cell identity associated with the eNB.

[00140] Example 46 comprises the subject matter of any variation of example 45, wherein the means for processing is further configured to select the common set of frequency domain resources based on the remainder resulting from dividing the

physical cell identity by n , wherein n is a number of distinct groups of cells for mitigation of inter-cell interference.

[00141] Example 47 comprises the subject matter of any variation of example 42, wherein the one or more parameters comprise the subframe used for the xSIB transmission.

[00142] Example 48 comprises the subject matter of any variation of any of examples 42-47, wherein the means for communication is further configured to transmit each physical xSIB channel via a xSIB block that comprises a plurality of demodulation reference signals (DM-RS) arranged based on a predetermined pattern.

[00143] Example 49 comprises the subject matter of any variation of example 48, wherein the plurality of DM-RS comprise DM-RS for a pair of antenna ports (APs), wherein the DM-RS for the pair of APs are multiplexed via frequency-division multiplexing (FDM).

[00144] Example 50 comprises the subject matter of any variation of example 48, wherein the plurality of DM-RS comprise DM-RS for a pair of antenna ports (APs), wherein the DM-RS for the pair of APs are multiplexed via code-division multiplexing (CDM) based on a pair of orthogonal cover codes (OCCs).

[00145] Example 51 comprises the subject matter of any variation of any of examples 42-47, wherein the means for communication is further configured to transmit each physical xSIB channel using Tx beams based on a predetermined Tx beam mapping between the xPBCH and the xSIB.

[00146] Example 52 comprises the subject matter of any variation of any of examples 1-16, further comprising the transceiver circuitry.

[00147] Example 53 comprises the subject matter of any variation of any of examples 1-16 or 52, wherein the physical xSIB channel is a dedicated channel.

[00148] Example 54 comprises the subject matter of any variation of any of examples 1-16 or 52, wherein the physical xSIB channel is a shared channel.

[00149] Example 55 comprises the subject matter of any variation of example 54, wherein the shared channel is a fifth generation (5G) physical downlink shared channel (xPDSCH).

[00150] Example 56 comprises the subject matter of any variation of any of examples 17-30, wherein each physical xSIB channel is a dedicated channel.

[00151] Example 58 comprises the subject matter of any variation of any of examples 17-30, wherein each physical xSIB channel is a shared channel.

[00152] Example 59 comprises the subject matter of any variation of example 58, wherein the shared channel is a fifth generation (5G) physical downlink shared channel (xPDSCH).

[00153] Example 60 comprises the subject matter of any variation of any of examples 31-41, further comprising the transceiver circuitry.

[00154] Example 61 comprises the subject matter of any variation of any of examples 31-41 or 60, wherein the physical xSIB channel is a dedicated channel.

[00155] Example 62 comprises the subject matter of any variation of any of examples 31-41 or 60, wherein the physical xSIB channel is a shared channel.

[00156] Example 63 comprises the subject matter of any variation of example 62, wherein the shared channel is a fifth generation (5G) physical downlink shared channel (xPDSCH).

[00157] Example 64 comprises the subject matter of any variation of any of examples 42-51, wherein each physical xSIB channel is a dedicated channel.

[00158] Example 65 comprises the subject matter of any variation of any of examples 42-51, wherein each physical xSIB channel is a shared channel.

[00159] Example 66 comprises the subject matter of any variation of example 65, wherein the shared channel is a fifth generation (5G) physical downlink shared channel (xPDSCH).

[00160] The above description of illustrated embodiments of the subject disclosure, including what is described in the Abstract, is not intended to be exhaustive or to limit the disclosed embodiments to the precise forms disclosed. While specific embodiments and examples are described herein for illustrative purposes, various modifications are possible that are considered within the scope of such embodiments and examples, as those skilled in the relevant art can recognize.

[00161] In this regard, while the disclosed subject matter has been described in connection with various embodiments and corresponding Figures, where applicable, it is to be understood that other similar embodiments can be used or modifications and additions can be made to the described embodiments for performing the same, similar, alternative, or substitute function of the disclosed subject matter without deviating therefrom. Therefore, the disclosed subject matter should not be limited to any single embodiment described herein, but rather should be construed in breadth and scope in accordance with the appended claims below.

[00162] In particular regard to the various functions performed by the above described components or structures (assemblies, devices, circuits, systems, etc.), the terms (including a reference to a "means") used to describe such components are intended to correspond, unless otherwise indicated, to any component or structure which performs the specified function of the described component (e.g., that is functionally equivalent), even though not structurally equivalent to the disclosed structure which performs the function in the herein illustrated exemplary implementations. In addition, while a particular feature may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular application.

CLAIMS

What is claimed is:

1. An apparatus configured to be employed within an Evolved NodeB (eNB), comprising one or more processors configured to:
 - generate a set of bits for a fifth generation (5G) System Information Block (xSIB);
 - apply coding to the set of bits for the xSIB to generate a coded set of xSIB bits;
 - scramble the coded set of xSIB bits to generate a scrambled set of xSIB bits;
 - modulate the scrambled set of xSIB bits to generate a modulated set of xSIB symbols;
 - map the modulated set of xSIB symbols to a set of frequency domain resources to generate a physical xSIB channel; and
 - output the physical xSIB channel to transceiver circuitry for transmission by a plurality of transmit (Tx) beams during a subframe, wherein the physical xSIB channel is output for transmission via one or more distinct Tx beams of the plurality of Tx beams during one or more of a plurality of distinct orthogonal frequency division multiplexing (OFDM) symbols of the subframe.
2. The apparatus of claim 1, wherein the one or more processors are further configured to output a 5G Master Information Block (xMIB) that indicates one or more of a payload size of the xSIB or a transmission duration of the xSIB.
3. The apparatus of claim 2, wherein the xMIB indicates a transmission periodicity of the xSIB.
4. The apparatus of claim 2, wherein a periodicity of the xSIB is based at least in part on the payload size of the xSIB.
5. The apparatus of claim 2, wherein the one or more processors are further configured to select the set of frequency domain resources based at least in part on the payload size of the xSIB.
6. The apparatus of any of claims 1-5, wherein, for each of the plurality of distinct OFDM symbols, the one or more distinct Tx beams comprise a single distinct Tx beam

for transmission of the physical xSIB channel via the entire set of frequency domain resources.

7. The apparatus of any of claims 1-5, wherein, for each of the plurality of distinct OFDM symbols, the one or more distinct Tx beams comprise two or more distinct Tx beams for transmission of the physical xSIB channel via a distinct subset of the set of frequency domain resources associated with that Tx beam of the two or more distinct Tx beams.

8. The apparatus of claim 7, wherein, for each of the two or more distinct Tx beams for each OFDM symbol, the distinct subset of the set of frequency domain resources associated with that Tx beam comprises a localized subset of the system bandwidth.

9. The apparatus of claim 7, wherein, for each of the two or more distinct Tx beams for each OFDM symbol, the distinct subset of the set of frequency domain resources associated with that Tx beam comprises a distributed subset of the system bandwidth.

10. The apparatus of any of claims 1-5, wherein the plurality of Tx beams is selected based on a predefined mapping between the xSIB and a set of Tx beams employed for transmission of one or more of synchronization signals, beam reference signals (BRSs) or a 5G physical broadcast channel (xPBCH).

11. A machine readable medium comprising instructions that, when executed, cause an Evolved NodeB (eNB) to:

determine a fifth generation (5G) System Information Block (xSIB);

transmit, via a 5G Physical Broadcast Channel (xPBCH), a 5G Master Information Block (xMIB) that indicates one or more parameters of the xSIB, wherein the one or more parameters comprise a payload size of the xSIB;

generate, for one or more orthogonal frequency division multiplexing (OFDM) symbols of a plurality of OFDM symbols of a subframe, a physical xSIB channel associated with that OFDM symbol, wherein each physical xSIB channel is generated based at least in part on the one or more parameters; and

transmit, during each OFDM symbol of the plurality of OFDM symbols and via a common set of frequency domain resources, the physical xSIB channel associated with that symbol via a distinct transmit (Tx) beam of a plurality of Tx beams.

12. The machine readable medium of claim 11, wherein the instructions, when executed, further cause the eNB to select the subframe or frame index based on a physical cell identity associated with the eNB.

13. The machine readable medium of claim 12, wherein the instructions, when executed, further cause the eNB to select the subframe or frame index based on the remainder resulting from dividing the physical cell identity by n , wherein n is a number of distinct groups of cells for mitigation of inter-cell interference.

14. The machine readable medium of claim 11, wherein the instructions, when executed, further cause the eNB to select the common set of frequency domain resources based on a physical cell identity associated with the eNB.

15. The machine readable medium of claim 14, wherein the instructions, when executed, further cause the eNB to select the common set of frequency domain resources based on the remainder resulting from dividing the physical cell identity by n , wherein n is a number of distinct groups of cells for mitigation of inter-cell interference.

16. The machine readable medium of claim 11, wherein the one or more parameters comprise the subframe used for the xSIB transmission.

17. The machine readable medium of any of claims 11-16, wherein the instructions, when executed, further cause the eNB to transmit each physical xSIB channel via a xSIB block that comprises a plurality of demodulation reference signals (DM-RS) arranged based on a predetermined pattern.

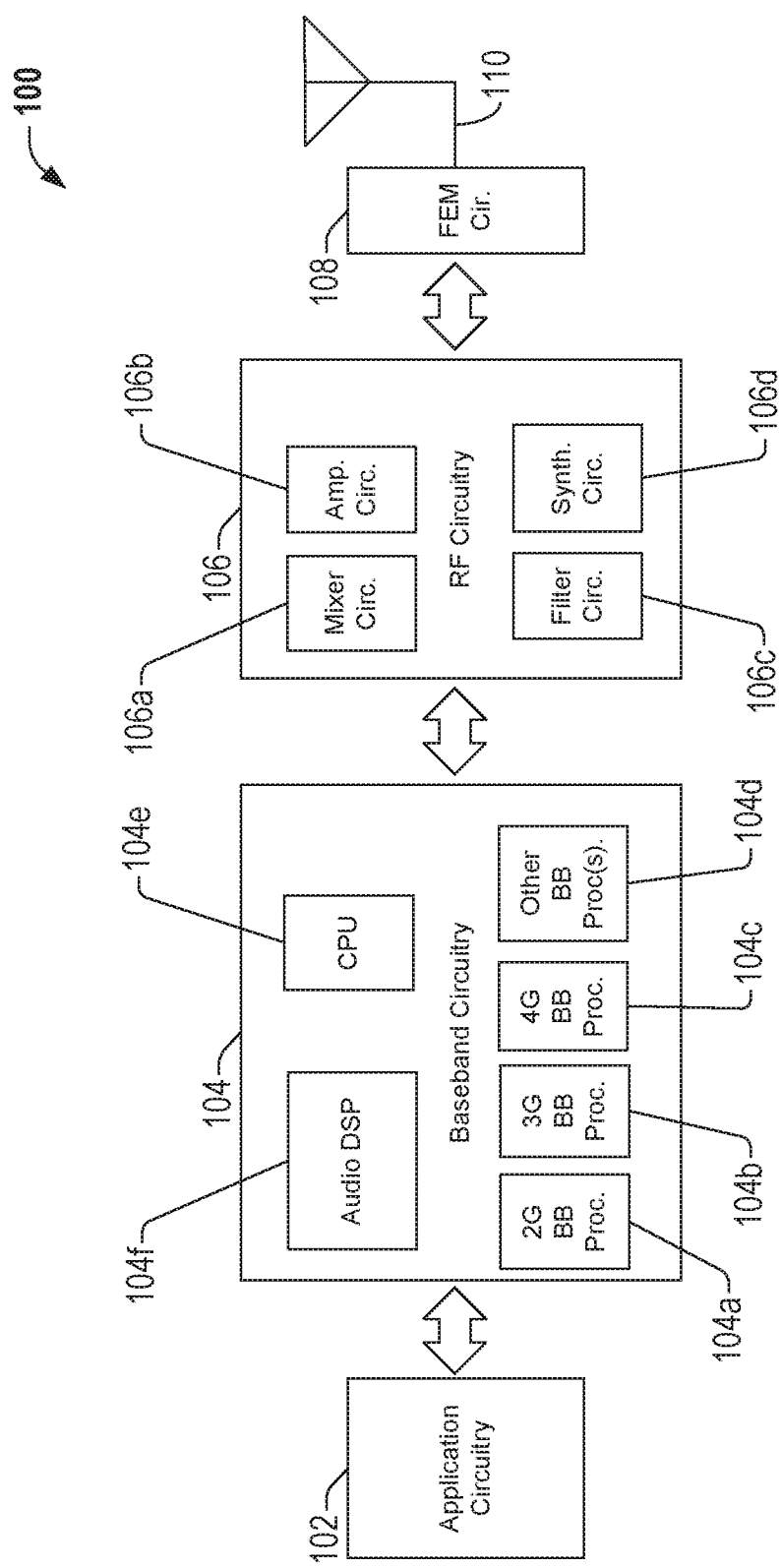
18. The machine readable medium of claim 17, wherein the plurality of DM-RS comprise DM-RS for a pair of antenna ports (APs), wherein the DM-RS for the pair of APs are multiplexed via frequency-division multiplexing (FDM).

19. The machine readable medium of claim 17, wherein the plurality of DM-RS comprise DM-RS for a pair of antenna ports (APs), wherein the DM-RS for the pair of APs are multiplexed via code-division multiplexing (CDM) based on a pair of orthogonal cover codes (OCCs).
20. The machine readable medium of any of claims 11-16, wherein the instructions, when executed, further cause the eNB to transmit each physical xSIB channel using Tx beams based on a predetermined Tx beam mapping between the xPBCH and the xSIB.
21. An apparatus configured to be employed within a User Equipment (UE), comprising one or more processors configured to:
- process a fifth generation (5G) Master Information Block (xMIB) received via transceiver circuitry;
 - determine, based on the xMIB, one or more parameters of a 5G System Information Block (xSIB); and
 - process a physical xSIB channel received from an Evolved NodeB (eNB) during a subframe by the transceiver circuitry, wherein the xSIB was transmitted by the eNB via a selected Tx beam over one or more given orthogonal frequency division multiplexing (OFDM) symbols of a plurality of OFDM symbols, wherein the given OFDM symbols are associated with the selected Tx beam.
22. The apparatus of claim 21, wherein the one or more parameters comprise a payload size of the xSIB.
23. The apparatus of claim 21, wherein the one or more parameters comprise a transmission periodicity of the xSIB.
24. The apparatus of any of claims 21-23, wherein the one or more parameters comprise the subframe used for the xSIB transmission.
25. The apparatus of any of claims 21-23, wherein the one or more processors are further configured to measure a distinct beam reference signal received power (BRS-RP) associated with each Tx beam of a set of Tx beams comprising the selected Tx

beam, wherein the selected Tx beam is selected based on the distinct BRS-RP associated with the selected Tx beam.

26. The apparatus of any of claims 21-23, wherein the one or more processors are further configured to determine the subframe based on a physical cell identity of the eNB.

27. The apparatus of any of claims 21-23, wherein the xSIB is received via a set of frequency domain resources based on a physical cell identity of the eNB.



Example UE

FIG. 1

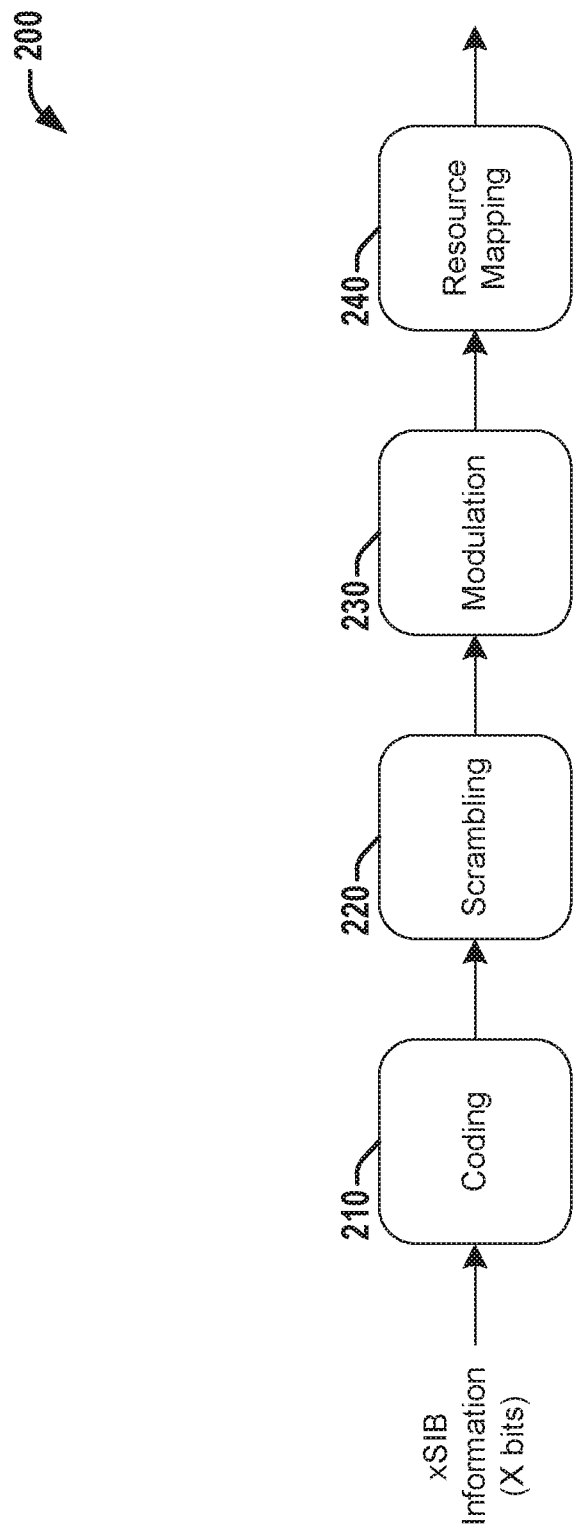


FIG. 2

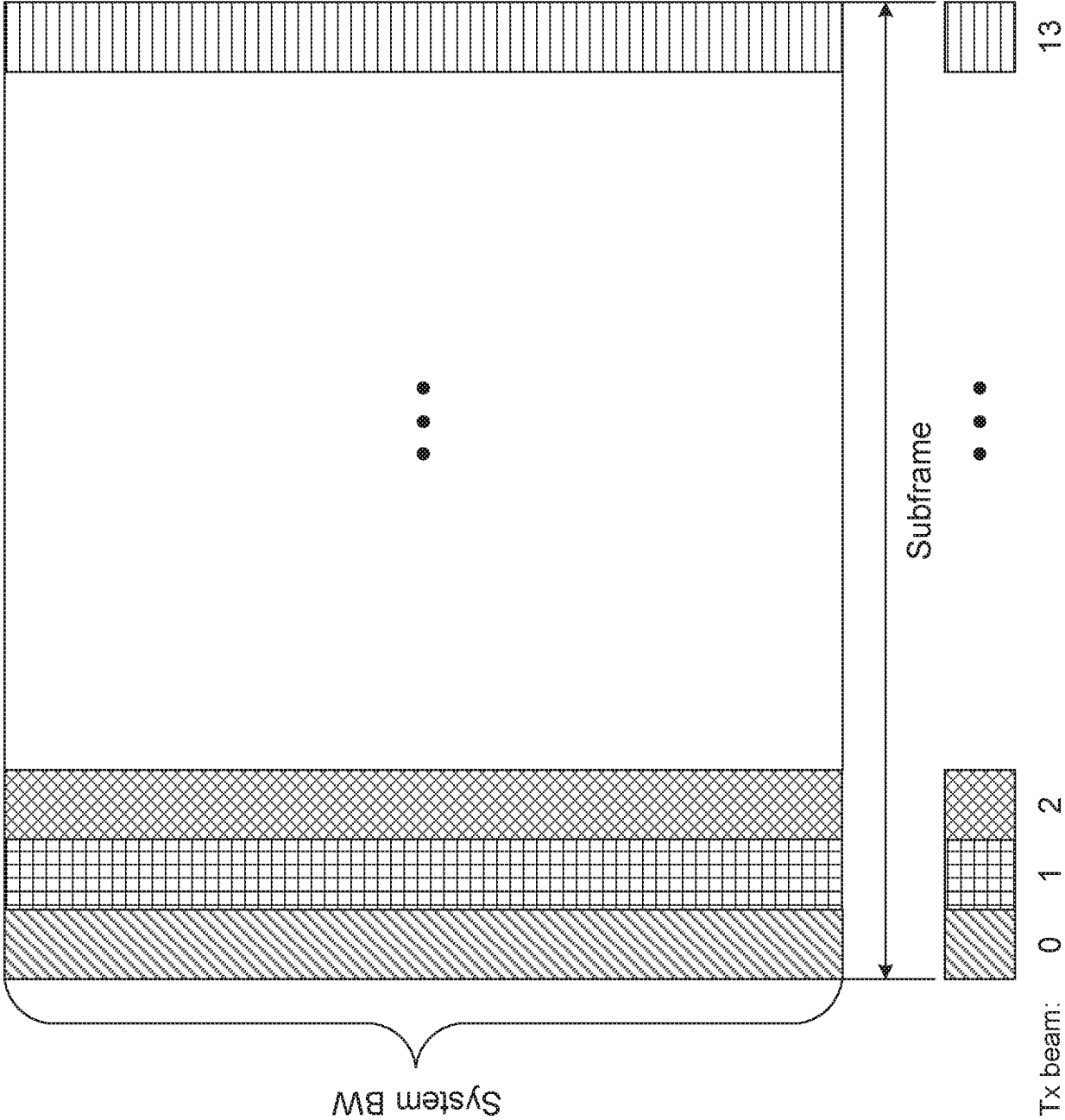


FIG. 3

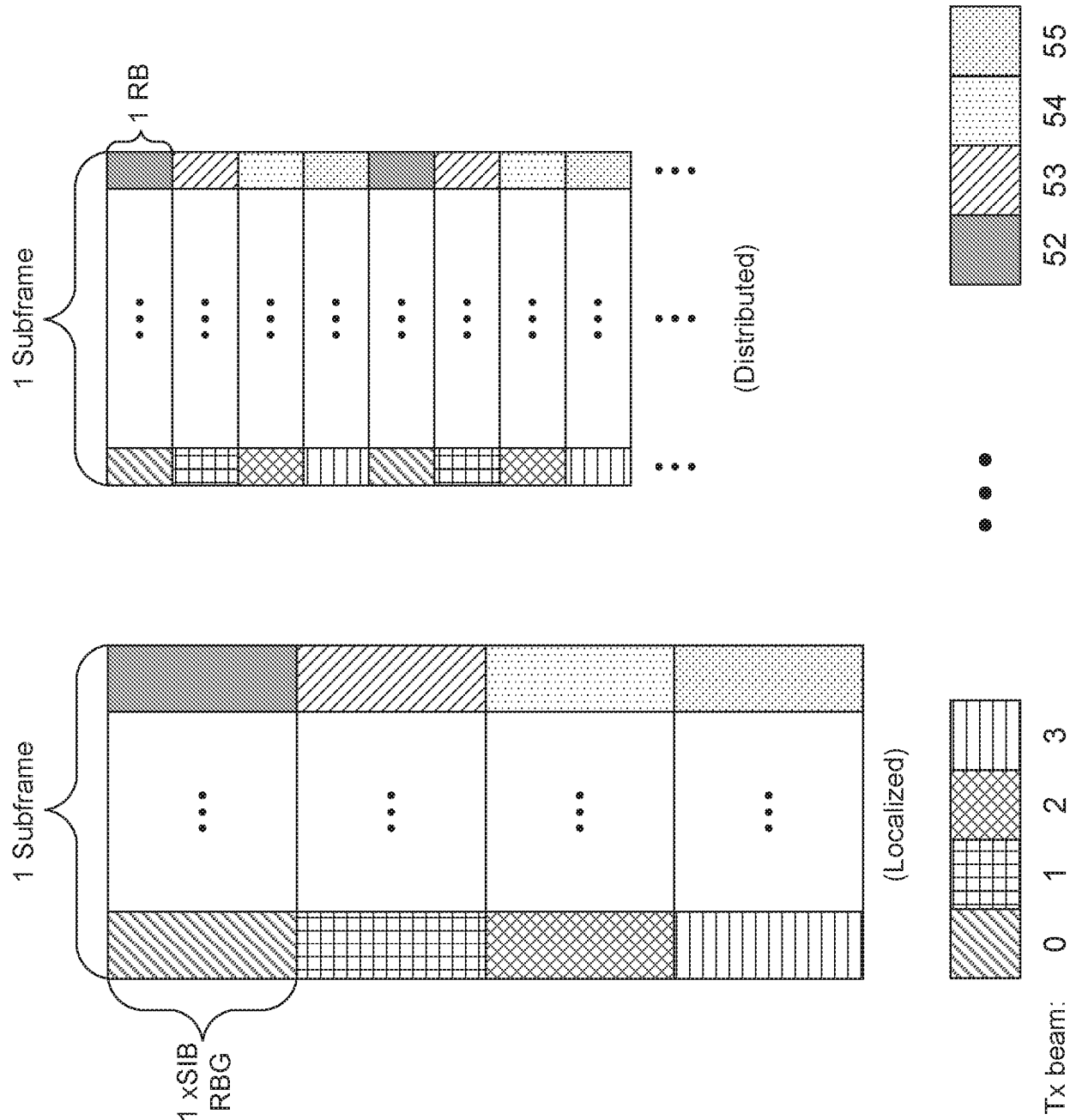


FIG. 4

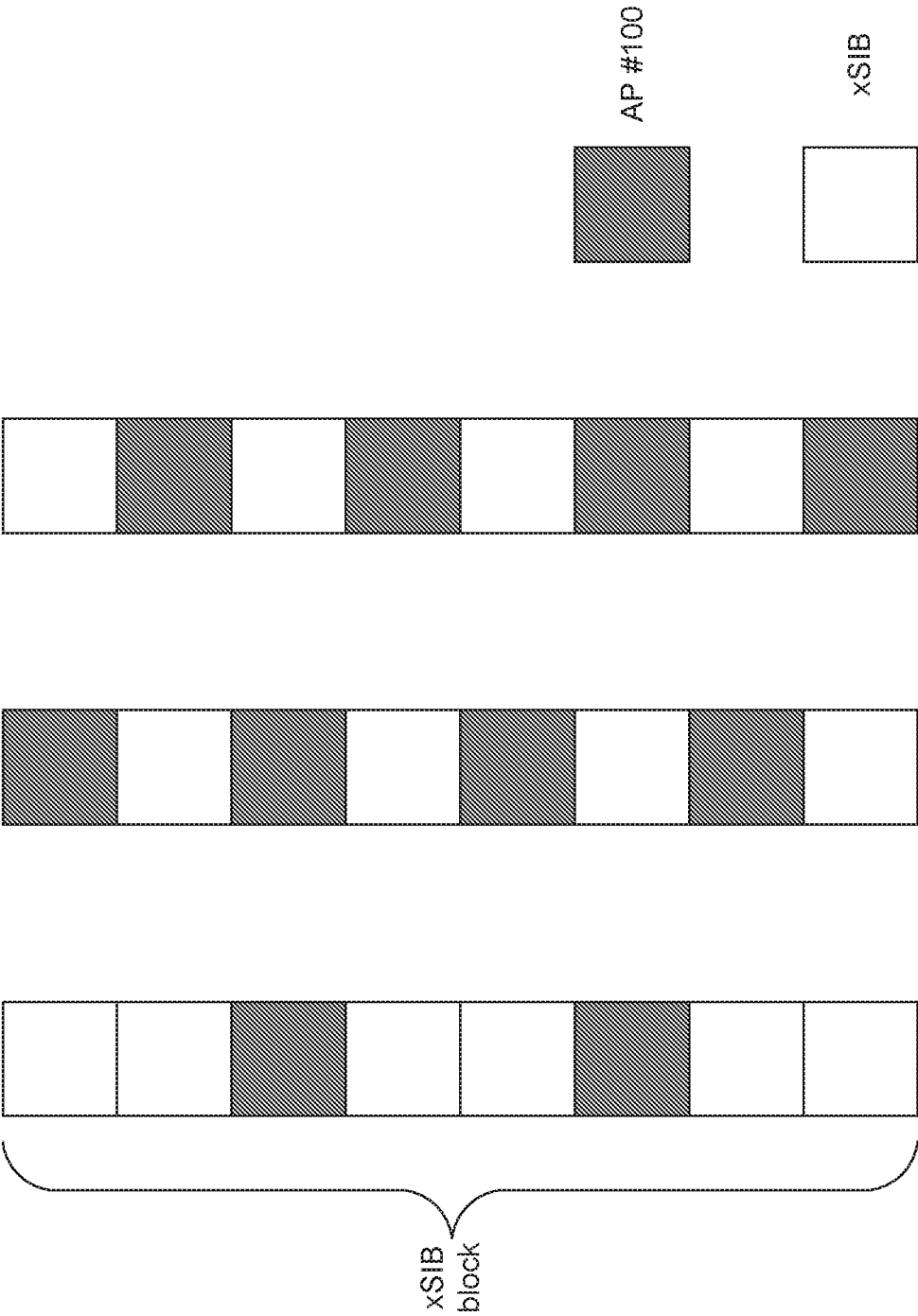


FIG. 5

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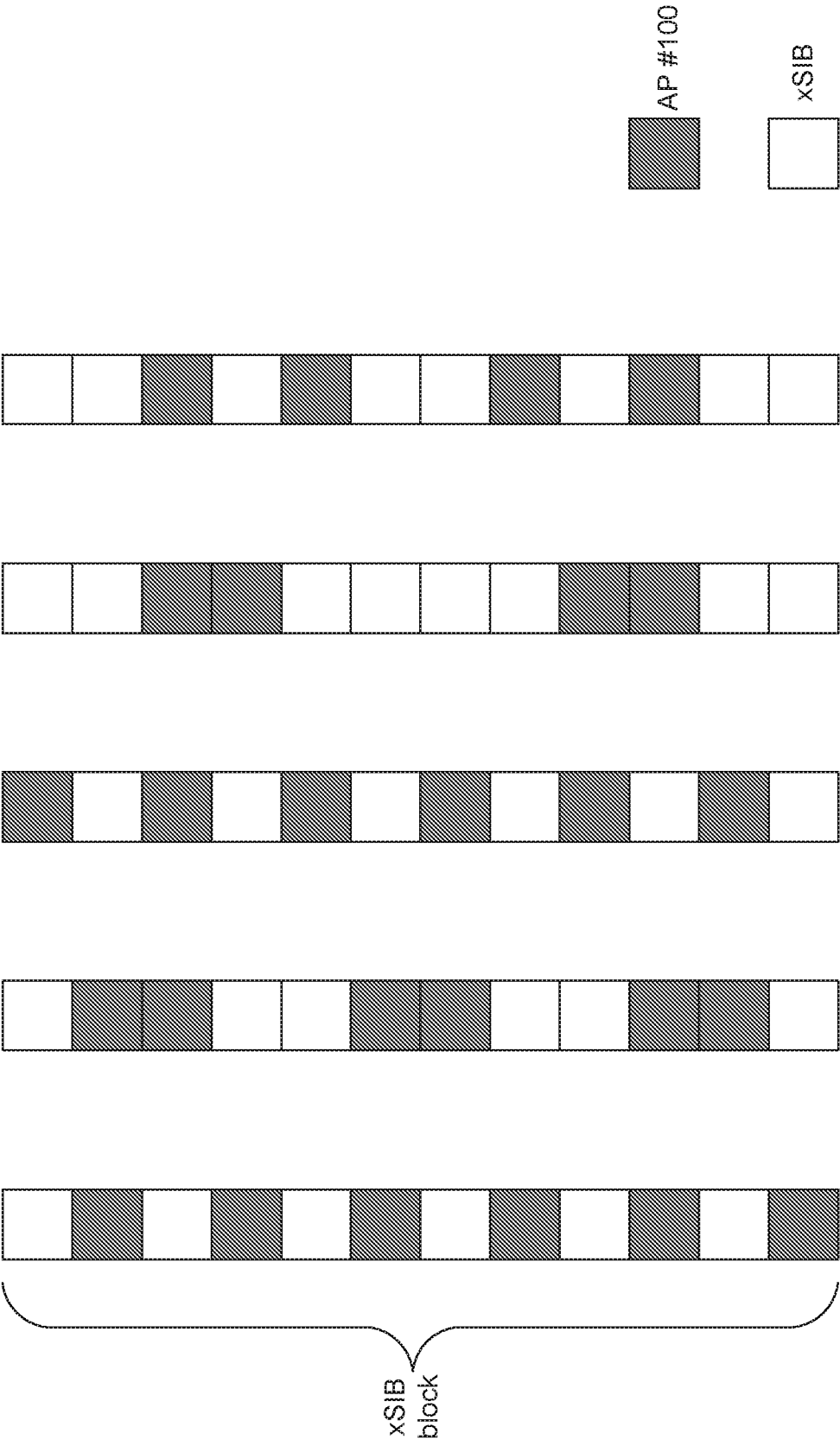


FIG. 6

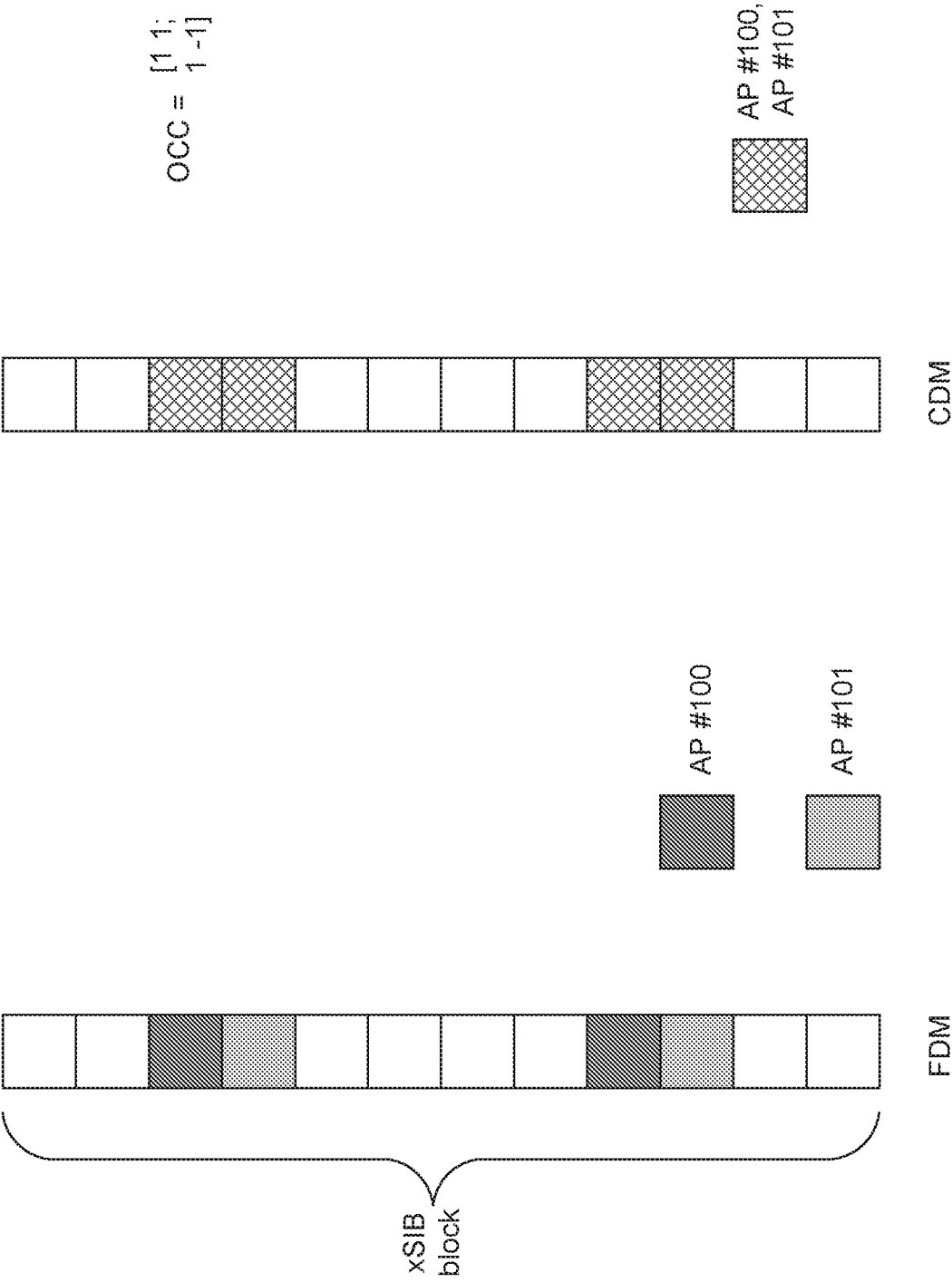


FIG. 7

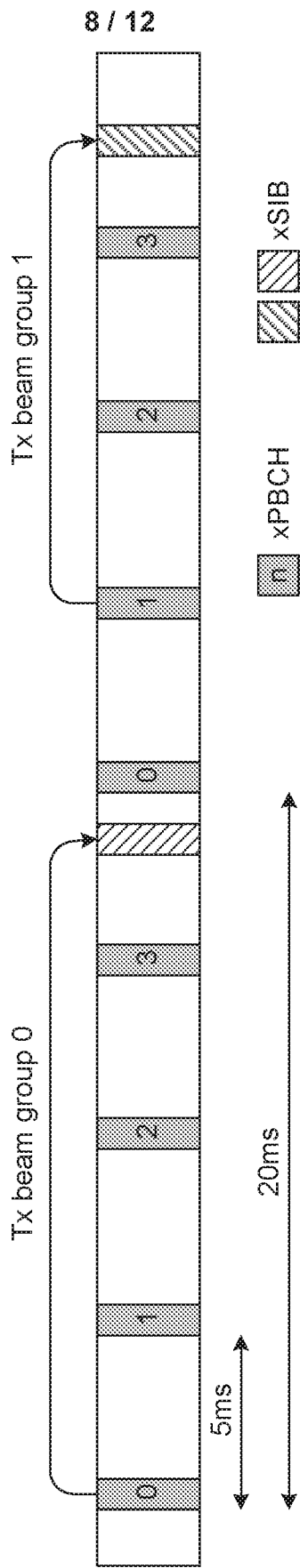


FIG. 8

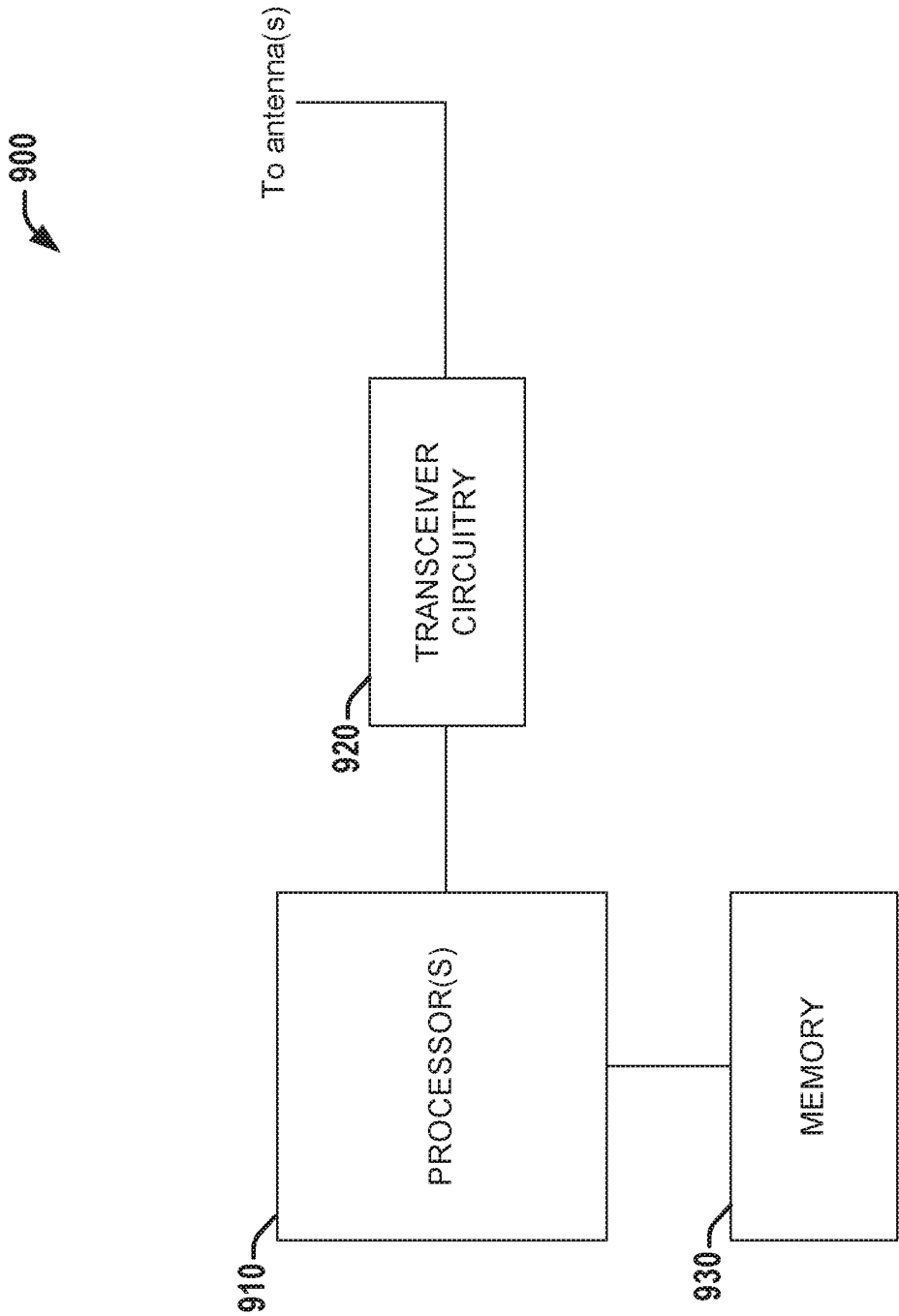


FIG. 9

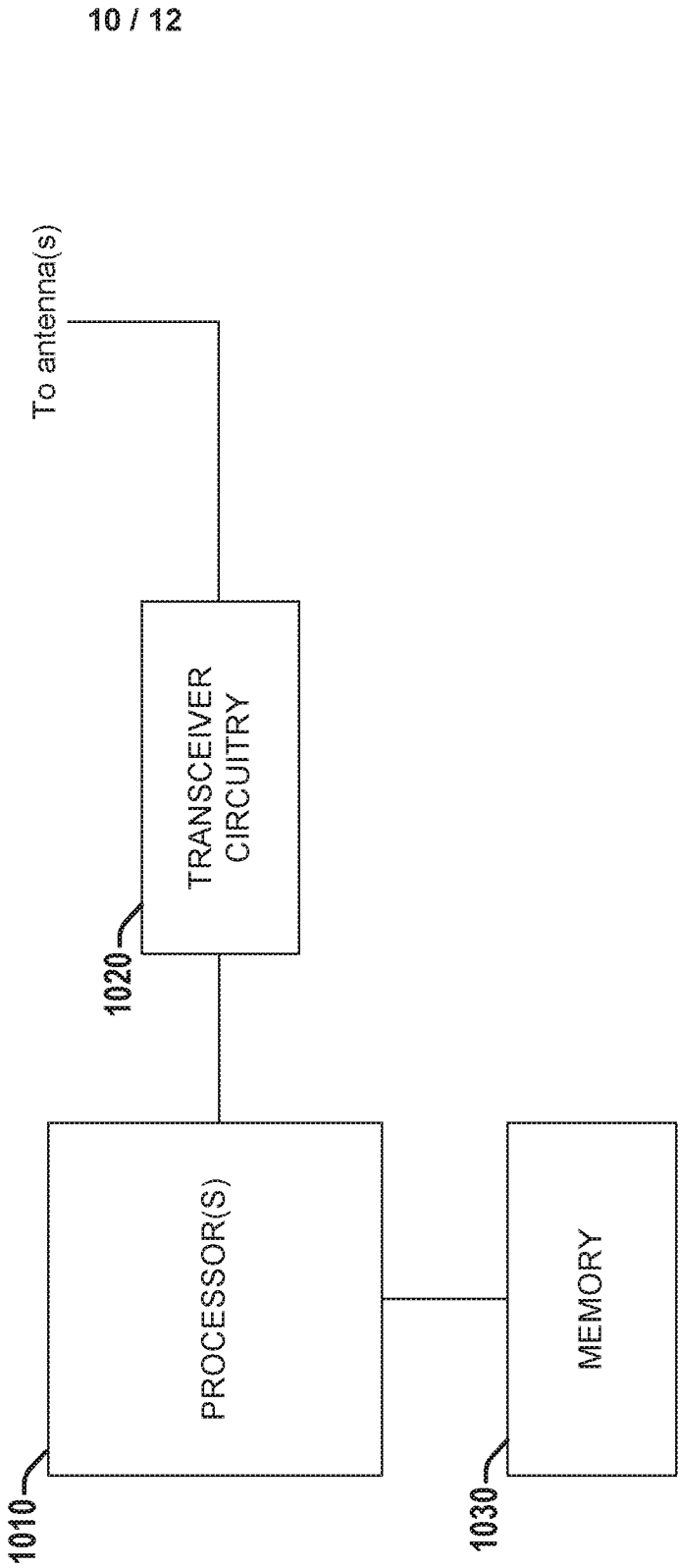


FIG. 10

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1100

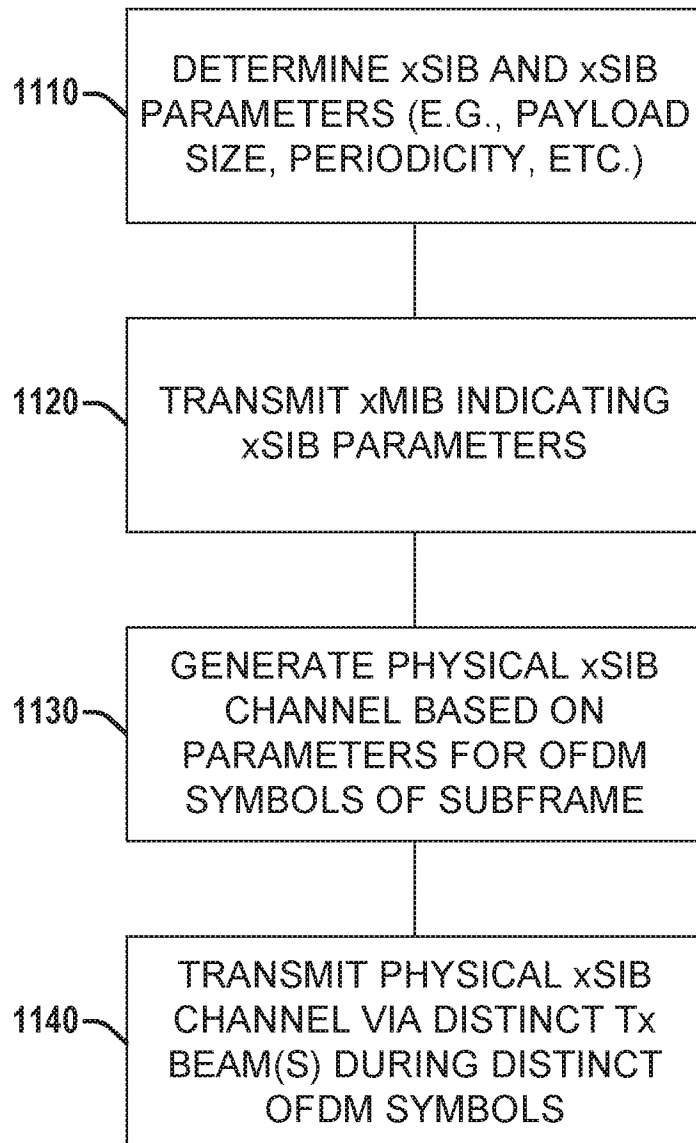


FIG. 11

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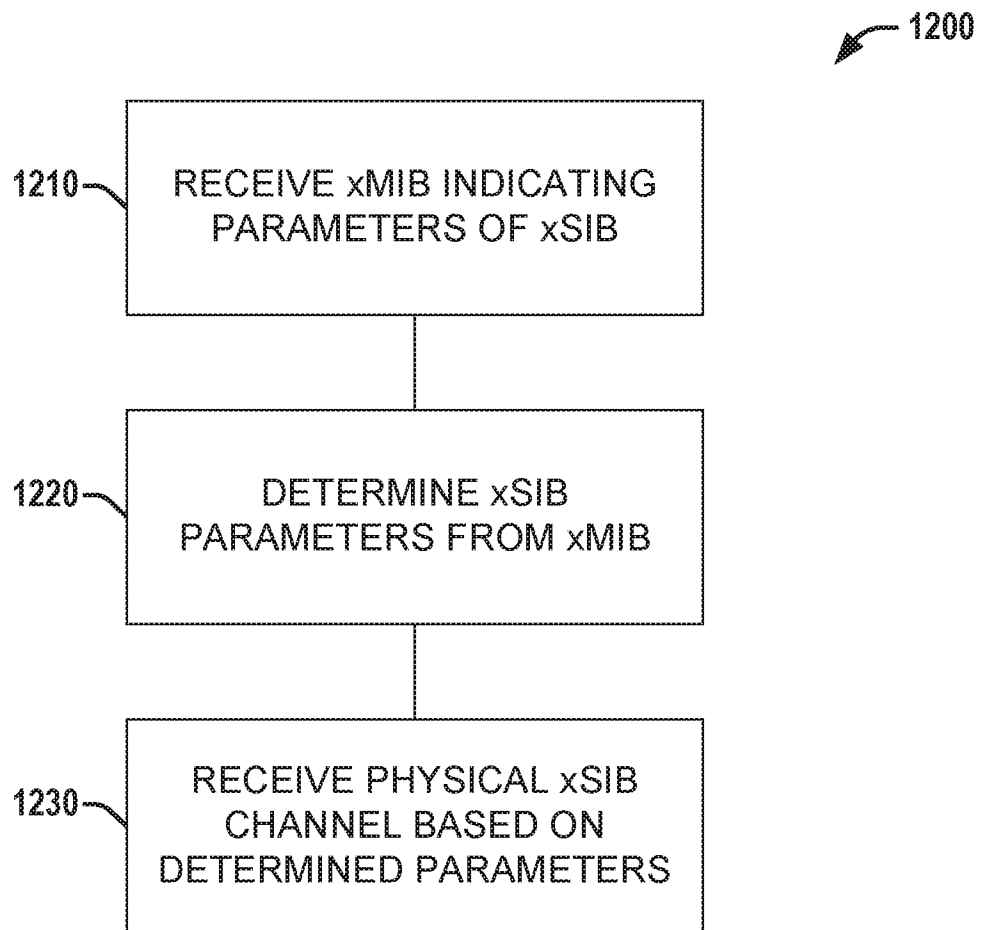


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/038936

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00
ADD.

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)
H04L

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/112220 A1 (KWAK YONGJUN [KR] ET AL) 24 April 2014 (2014-04-24)	1-3,6-27
A	figure 5 paragraph [0067] - paragraph [0069] -----	4,5
X	US 2014/177607 A1 (LI YING [US] ET AL) 26 June 2014 (2014-06-26)	1-3,6-27
A	figures 10A-10D paragraph [0129] - paragraph [0132] paragraph [0263] - paragraph [0273] -----	4,5
A	Erik Dahlman ET AL: "Access Procedures (Chapter 14)" In: "4G LTE/LTE-Advanced for Mobile Broadband", 29 March 2011 (2011-03-29), Academic Press in Elsevier, XP055061127, pages 301-321, page 304 - page 310 -----	1-27



Further documents are listed in the continuation of Box C.



See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search

18 November 2016

Date of mailing of the international search report

28/11/2016

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/038936

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014112220 A1	24-04-2014	US 2014112220 A1 WO 2014065600 A1	24-04-2014 01-05-2014
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