

METHODS AND APPARATUS SUPPORTING TWO SEPARATE CLOSED LOOP POWER CONTROL ADJUSTMENT STATES FOR SRS TRANSMISSIONS

TECHNICAL FIELD

[0001] The present disclosure relates to wireless communications, and more specifically to methods and apparatus supporting two separate closed loop power control adjustment states for SRS transmissions.

BACKGROUND

[0002] A wireless communications system may include one or multiple network communication devices, such as base stations, which may support wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications with one or multiple user communication devices by utilizing resources of the wireless communication system (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers, or the like). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, among other suitable radio access technologies beyond 5G (e.g., sixth generation (6G)).

[0003] The following abbreviations and acronyms are herewith defined, at least some of which are referred to within the specification:

[0004] Third Generation Partnership Project (3GPP), New Radio (NR), 5G-Advanced (5G-A), 5G Ultrawideband (5G-UWB), Long Term Evolution (LTE), LTE Advanced (LTE-A), Worldwide Interoperability for Microwave Access (WiMAX), E-UTRAN Node

B (eNB), Radio Access Network (RAN), Internet of Things (IoT), Internet-of-Everything (IoE), Machine Type Communication (MTC), Orthogonal Frequency Division Multiplexing (OFDM), Downlink (DL), Uplink (UL), User Equipment (UE), Network Equipment (NE), Receive or Receiver (RX, or Rx), Transmit or Transmitter (TX, or Tx), 5G Core (5GC), Core Network (CN), Frequency Range 1 (FR1), Frequency Range 2 (FR2), Device to Device (D2D), Vehicle-to-Vehicle (V2V), Vehicle-to-Everything (V2X), Access Node Controller (ANC), Transmission Reception Point (TRP), Mobility Management Entity (MME), Access and Mobility Management Function (AMF), Serving Gateway (S-GW), Packet Data Network (PDN), Packet Data Network Gateway (P-GW), User Plane Function (UPF), Non-Access Stratum (NAS), Protocol Data Unit (PDU), Digital Signal Processor (DSP), Application-Specific Integrated Circuit (ASIC), Amplitude Modulation (AM), Frequency Modulation (FM), Phase-Shift Keying (PSK), Quadrature amplitude modulation (QAM), Arithmetic-Logic Unit (ALU), Random Access Memory (RAM), Read-Only Memory (ROM), Dynamic RAM (DRAM), Synchronous Dynamic RAM (SDRAM), Static RAM (SRAM), Ferroelectric RAM (FeRAM), Magnetic RAM (MRAM), Resistive RAM (RRAM), Phase Change Memory (PCM), Index/Identifier (ID), Low-Noise Amplifier (LNA), Code-Division Multiple Access (CDMA), Frequency Division Multiple Access (FDMA), Time-Division Multiple Access (TDMA), Physical Downlink Control Channel (PDCCH), Physical Uplink Control Channel (PUCCH), Physical Uplink Shared Channel (PUSCH), Physical Random Access Channel (PRACH), Bandwidth Part (BWP), Control Resource Set (CORESET), Cyclic Redundancy Check (CRC), Channel State Information (CSI), Downlink Control Information (DCI), Non-Access Stratum (NAS), Random Access Response (RAR), Radio Network Temporary Identifier (RNTI), Radio Resource Control (RRC), Subcarrier Spacing (SCS), Sounding Reference Signal (SRS), Band Category (BC), Evolved Packet Core (EPC), Institute of Electrical and Electronics Engineers (IEEE), Maximum Power Reduction (MPR), Transmission Configuration Indication (TCI), Technical Specification (TS), Transmit Power Control (TPC), Transmit Power Control - Sounding Reference Signal - Radio Network Temporary Identifier (TPC-SRS-RNTI), Transmission Comb (TC), Path Loss (PL), Power Control (PC).

SUMMARY

[0005] An article “a” before an element is unrestricted and understood to refer to “at least one” of those elements or “one or more” of those elements. The terms “a,” “at least one,” “one or more,” and “at least one of one or more” may be interchangeable. As used herein, including in the claims, “or” as used in a list of items (e.g., a list of items prefaced by a phrase such as “at least one of” or “one or more of” or “one or both of”) indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Also, as used herein, the phrase “based on” shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as “based on condition A” may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase “based on” shall be construed in the same manner as the phrase “based at least in part on. Further, as used herein, including in the claims, a “set” may include one or more elements.

[0006] Some implementations of the method and apparatuses described herein may include a user equipment (UE) for wireless communication, comprising: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the UE to: receive a Radio Resource Control (RRC) configuration of two separate closed loop power control adjustment states for Sounding Reference Signal (SRS) transmissions; receive Downlink Control Information (DCI) indicating Transmit Power Control (TPC) command for an SRS transmission configured with one of the separate closed loop power control adjustment states; and determine transmission power for the SRS transmission based on its separate closed loop power control adjustment state.

[0007] Some implementations of the method and apparatuses described herein may include a processor for wireless communication, comprising: at least one controller coupled with at least one memory and configured to cause the processor to: receive a Radio Resource Control (RRC) configuration of two separate closed loop power control adjustment states for Sounding Reference Signal (SRS) transmissions; receive Downlink Control Information (DCI) indicating Transmit Power Control (TPC) command for an SRS

transmission configured with one of the separate closed loop power control adjustment states; and determine transmission power for the SRS transmission based on its separate closed loop power control adjustment state

[0008] Some implementations of the method and apparatuses described herein may include a method performed by a user equipment (UE), the method comprising: receiving a Radio Resource Control (RRC) configuration of two separate closed loop power control adjustment states for Sounding Reference Signal (SRS) transmissions; receiving Downlink Control Information (DCI) indicating Transmit Power Control (TPC) command for an SRS transmission configured with one of the separate closed loop power control adjustment states; and determining transmission power for the SRS transmission based on its separate closed loop power control adjustment state.

[0009] In some implementations of the method and apparatuses described herein, the DCI is DCI format 2_3 indicating TPC command for the SRS transmission with one of the separate closed loop power control adjustment states.

[0010] In some implementations of the method and apparatuses described herein, the DCI format 2_3 comprises a block configured to the UE that includes a field to indicate one of the separate closed loop power control adjustment states with which the TPC command of the block is associated.

[0011] In some implementations of the method and apparatuses described herein, for TPC type A, the field is one bit where two separate closed loop power control adjustment states are configured for SRS transmissions in at least one Uplink (UL) carrier provided by higher layer parameter *cc-IndexInOneCC-Set*, and zero bit otherwise.

[0012] In some implementations of the method and apparatuses described herein, for TPC type B, the field is one bit where two separate closed loop power control adjustment states are configured for SRS transmissions, and zero bit otherwise.

[0013] In some implementations of the method and apparatuses described herein, two Transmit Power Control - Sounding Reference Signal - Radio Network Temporary Identifiers (TPC-SRS-RNTIs) are configured by RRC.

[0014] In some implementations of the method and apparatuses described herein, the DCI format 2_3 with Cyclic Redundancy Check (CRC) scrambled with different TPC-SRS-

RNTIs are used for the transmission of TPC commands for SRS transmissions with different closed loop PC power control states.

[0015] In some implementations of the method and apparatuses described herein, the DCI is DCI format 2_3 including TPC commands for SRS transmissions where different SRS transmissions are with different separate closed loop power control adjustment states.

[0016] In some implementations of the method and apparatuses described herein, two consecutive blocks in the DCI format 2_3 are used for indicating TPC commands for SRS transmissions, and each of the two consecutive blocks includes TPC command for SRS transmission with each of the two separate closed loop power control adjustment states.

[0017] In some implementations of the method and apparatuses described herein, the two consecutive blocks are fixedly associated with the two separate closed loop power control adjustment states in a one-to-one manner.

[0018] In some implementations of the method and apparatuses described herein, each one of the two consecutive blocks comprises an SRS request, and is associated with the closed loop power control adjustment state as the configured state for the SRS transmissions triggered by the SRS request.

[0019] In some implementations of the method and apparatuses described herein, a block in the DCI format 2_3 includes two groups of TPC commands with each group being for SRS transmission with each of the two separate closed loop power control adjustment states.

[0020] In some implementations of the method and apparatuses described herein, the DCI is DCI format 2_3 and start bit of a block is configured to a value of an integer larger than 31.

[0021] In some implementations of the method and apparatuses described herein, the transmission power for the SRS transmission is determined with an adjustment part calculated based on its separate closed loop power control adjustment state.

[0022] In some implementations of the method and apparatuses described herein, the separate closed loop power control adjustment state for the SRS transmission is configured in *p0AlphaSetforSRS*.

[0023] In some implementations of the method and apparatuses described herein, the separate closed loop power control adjustment state for the SRS transmission is configured in an SRS resource set.

[0024] In some implementations of the method and apparatuses described herein, the at least one processor is further configured to cause the UE to transmit a report that two separate closed loop power control adjustment states for SRS transmissions are supported.

[0025] Some implementations of the method and apparatuses described herein may include a base station for wireless communication, comprising: at least one memory; and at least one processor coupled with the at least one memory and configured to cause the base station to: transmit a Radio Resource Control (RRC) configuration of two separate closed loop power control adjustment states for Sounding Reference Signal (SRS) transmissions; and transmit Downlink Control Information (DCI) indicating Transmit Power Control (TPC) command for an SRS transmission configured with one of the separate closed loop power control adjustment states.

[0026] Some implementations of the method and apparatuses described herein may include a processor for wireless communication, comprising: at least one controller coupled with at least one memory and configured to cause the processor to: transmit a Radio Resource Control (RRC) configuration of two separate closed loop power control adjustment states for Sounding Reference Signal (SRS) transmissions; and transmit Downlink Control Information (DCI) indicating Transmit Power Control (TPC) command for an SRS transmission configured with one of the separate closed loop power control adjustment states.

[0027] Some implementations of the method and apparatuses described herein may include a method performed by a base station for wireless communication, the method comprising: transmitting a Radio Resource Control (RRC) configuration of two separate closed loop power control adjustment states for Sounding Reference Signal (SRS) transmissions; and transmitting Downlink Control Information (DCI) indicating Transmit Power Control (TPC) command for an SRS transmission configured with one of the separate closed loop power control adjustment states.

[0028] In some implementations of the method and apparatuses described herein, the DCI is DCI format 2_3 indicating TPC command for the SRS transmission with one of the separate closed loop power control adjustment states.

[0029] In some implementations of the method and apparatuses described herein, the DCI format 2_3 comprises a block configured to the UE that includes a field to indicate one of the separate closed loop power control adjustment states with which the TPC command of the block is associated.

[0030] In some implementations of the method and apparatuses described herein, for TPC type A, the field is one bit where two separate closed loop power control adjustment states are configured for SRS transmissions in at least one Uplink (UL) carrier provided by higher layer parameter *cc-IndexInOneCC-Set*, and zero bit otherwise.

[0031] In some implementations of the method and apparatuses described herein, for TPC type B, the field is one bit where two separate closed loop power control adjustment states are configured for SRS transmissions, and zero bit otherwise.

[0032] In some implementations of the method and apparatuses described herein, two Transmit Power Control - Sounding Reference Signal - Radio Network Temporary Identifiers (TPC-SRS-RNTIs) are configured by RRC.

[0033] In some implementations of the method and apparatuses described herein, the DCI format 2_3 with Cyclic Redundancy Check (CRC) scrambled with different TPC-SRS-RNTIs are used for the transmission of TPC commands for SRS transmissions with different closed loop PC power control states.

[0034] In some implementations of the method and apparatuses described herein, the DCI is DCI format 2_3 including TPC commands for SRS transmissions where different SRS transmissions are with different separate closed loop power control adjustment states.

[0035] In some implementations of the method and apparatuses described herein, two consecutive blocks in the DCI format 2_3 are used for indicating TPC commands for SRS transmissions, and each of the two consecutive blocks includes TPC command for SRS transmission with each of the two separate closed loop power control adjustment states.

[0036] In some implementations of the method and apparatuses described herein, the two consecutive blocks are fixedly associated with the two separate closed loop power control adjustment states in a one-to-one manner.

[0037] In some implementations of the method and apparatuses described herein, each one of the two consecutive blocks comprises an SRS request, and is associated with the closed loop power control adjustment state as the configured state for the SRS transmissions triggered by the SRS request.

[0038] In some implementations of the method and apparatuses described herein, a block in the DCI format 2_3 includes two groups of TPC commands with each group being for SRS transmission with each of the two separate closed loop power control adjustment states.

[0039] In some implementations of the method and apparatuses described herein, the DCI is DCI format 2_3 and start bit of a block is configured to a value of an integer larger than 31.

[0040] In some implementations of the method and apparatuses described herein, the separate closed loop power control adjustment state for the SRS transmission is configured in $p0AlphaSet$ for SRS.

[0041] In some implementations of the method and apparatuses described herein, the separate closed loop power control adjustment state for the SRS transmission is configured in an SRS resource set.

[0042] In some implementations of the method and apparatuses described herein, the at least one processor is further configured to receive a report that two separate closed loop power control adjustment states for SRS transmissions are supported by a UE.

BRIEF DESCRIPTION OF THE DRAWINGS

[0043] Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

[0044] Figure 2 illustrates an example of a user equipment (UE) 200 in accordance with aspects of the present disclosure.

[0045] Figure 3 illustrates an example of a processor 300 in accordance with aspects of the present disclosure.

[0046] Figure 4 illustrates an example of a network equipment (NE) 400 in accordance with aspects of the present disclosure.

[0047] Figure 5 illustrates an example of UE transmitting UL signal to a micro node but receiving DL signal from a macro gNB in accordance with aspects of the present disclosure.

[0048] Figure 6 illustrates a flowchart of method performed by a UE in accordance with aspects of the present disclosure.

[0049] Figure 7 illustrates a flowchart of method performed by a NE in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

[0050] Aspects of the present disclosure are described in the context of a wireless communications system.

[0051] Figure 1 illustrates an example of a wireless communications system 100 in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more NE 102, one or more UE 104, and a core network (CN) 106. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a New Radio (NR) network, such as a 5G network, a 5G-Advanced (5G-A) network, or a 5G ultrawideband (5G-UWB) network. In other implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G, for example, 6G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple

access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

[0052] The one or more NE 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the NE 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a network function, a network entity, a radio access network (RAN), a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. An NE 102 and a UE 104 may communicate via a communication link, which may be a wireless or wired connection. For example, an NE 102 and a UE 104 may perform wireless communication (e.g., receive signaling, transmit signaling) over a Uu interface.

[0053] An NE 102 may provide a geographic coverage area for which the NE 102 may support services for one or more UEs 104 within the geographic coverage area. For example, an NE 102 and a UE 104 may support wireless communication of signals related to services (e.g., voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, an NE 102 may be moveable, for example, a satellite associated with a non-terrestrial network (NTN). In some implementations, different geographic coverage areas 112 associated with the same or different radio access technologies may overlap, but the different geographic coverage areas may be associated with different NE 102.

[0054] The one or more UE 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a remote unit, a mobile device, a wireless device, a remote device, a subscriber device, a transmitter device, a receiver device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples.

[0055] A UE 104 may be able to support wireless communication directly with other UEs 104 over a communication link. For example, a UE 104 may support wireless

communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link 114 may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

[0056] An NE 102 may support communications with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with other NE 102 or the CN 106 through one or more backhaul links (e.g., S1, N2, N2, or network interface). In some implementations, the NE 102 may communicate with each other directly. In some other implementations, the NE 102 may communicate with each other or indirectly (e.g., via the CN 106). In some implementations, one or more NE 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

[0057] The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g., a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g., a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g., data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more NE 102 associated with the CN 106.

[0058] The CN 106 may communicate with a packet data network over one or more backhaul links (e.g., via an S1, N2, N2, or another network interface). The packet data network may include an application server. In some implementations, one or more UEs 104 may communicate with the application server. A UE 104 may establish a session (e.g., a

protocol data unit (PDU) session, or the like) with the CN 106 via an NE 102. The CN 106 may route traffic (e.g., control information, data, and the like) between the UE 104 and the application server using the established session (e.g., the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the CN 106 (e.g., one or more network functions of the CN 106).

[0059] In the wireless communications system 100, the NEs 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g., time resources (e.g., symbols, slots, subframes, frames, or the like) or frequency resources (e.g., subcarriers, carriers)) to perform various operations (e.g., wireless communications). In some implementations, the NEs 102 and the UEs 104 may support different resource structures. For example, the NEs 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the NEs 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the NEs 102 and the UEs 104 may support various frame structures (i.e., multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

[0060] One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g., $\mu=0$) may be associated with a first subcarrier spacing (e.g., 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g., $\mu=0$) associated with the first subcarrier spacing (e.g., 15 kHz) may utilize one slot per subframe. A second numerology (e.g., $\mu=1$) may be associated with a second subcarrier spacing (e.g., 30 kHz) and a normal cyclic prefix. A third numerology (e.g., $\mu=2$) may be associated with a third subcarrier spacing (e.g., 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g., $\mu=3$) may be associated with a fourth subcarrier spacing (e.g., 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g., $\mu=4$) may be associated with a fifth subcarrier spacing (e.g., 240 kHz) and a normal cyclic prefix.

[0061] A time interval of a resource (e.g., a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for

example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

[0062] Additionally or alternatively, a time interval of a resource (e.g., a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g., quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e., $\mu=0$, $\mu=1$, $\mu=2$, $\mu=3$, $\mu=4$) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g., quantity) of symbols (e.g., OFDM symbols). In some implementations, the number (e.g., quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g., applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g., $\mu=0$) associated with a first subcarrier spacing (e.g., 15 kHz) may be used interchangeably between subframes and slots.

[0063] In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the NEs 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In

some implementations, FR1 may be used by the NEs 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g., control information, data). In some implementations, FR2 may be used by the NEs 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

[0064] FR1 may be associated with one or multiple numerologies (e.g., at least three numerologies). For example, FR1 may be associated with a first numerology (e.g., $\mu=0$), which includes 15 kHz subcarrier spacing; a second numerology (e.g., $\mu=1$), which includes 30 kHz subcarrier spacing; and a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g., at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g., $\mu=2$), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g., $\mu=3$), which includes 120 kHz subcarrier spacing.

[0065] Figure 2 illustrates an example of a UE 200 in accordance with aspects of the present disclosure. The UE 200 may include a processor 202, a memory 204, a controller 206, and a transceiver 208. The processor 202, the memory 204, the controller 206, or the transceiver 208, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0066] The processor 202, the memory 204, the controller 206, or the transceiver 208, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0067] The processor 202 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 202 may be configured to operate the memory 204. In some other implementations, the memory 204 may be integrated into the processor 202.

The processor 202 may be configured to execute computer-readable instructions stored in the memory 204 to cause the UE 200 to perform various functions of the present disclosure.

[0068] The memory 204 may include volatile or non-volatile memory. The memory 204 may store computer-readable, computer-executable code including instructions when executed by the processor 202 cause the UE 200 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 204 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[0069] In some implementations, the processor 202 and the memory 204 coupled with the processor 202 may be configured to cause the UE 200 to perform one or more of the functions described herein (e.g., executing, by the processor 202, instructions stored in the memory 204). For example, the processor 202 may support wireless communication at the UE 200 in accordance with examples as disclosed herein.

[0070] The controller 206 may manage input and output signals for the UE 200. The controller 206 may also manage peripherals not integrated into the UE 200. In some implementations, the controller 206 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 206 may be implemented as part of the processor 202.

[0071] In some implementations, the UE 200 may include at least one transceiver 208. In some other implementations, the UE 200 may have more than one transceiver 208. The transceiver 208 may represent a wireless transceiver. The transceiver 208 may include one or more receiver chains 210, one or more transmitter chains 212, or a combination thereof.

[0072] A receiver chain 210 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 210 may include one or more antennas for receive the signal over the air or wireless medium.

The receiver chain 210 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 210 may include at least one demodulator configured to demodulate the received signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 210 may include at least one decoder for decoding the processed demodulated signal to receive the transmitted data.

[0073] A transmitter chain 212 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 212 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 212 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 212 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0074] Figure 3 illustrates an example of a processor 300 in accordance with aspects of the present disclosure. The processor 300 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 300 may include a controller 302 configured to perform various operations in accordance with examples as described herein. The processor 300 may optionally include at least one memory 304, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 300 may optionally include one or more arithmetic-logic units (ALUs) 306. One or more of these components may be in electronic communication or otherwise coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g., buses).

[0075] The processor 300 may be a processor chipset and include a protocol stack (e.g., a software stack) executed by the processor chipset to perform various operations (e.g., receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining,

identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g., memory local to or included in the processor chipset (e.g., the processor 300) or other memory (e.g., random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

[0076] The controller 302 may be configured to manage and coordinate various operations (e.g., signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 300 to cause the processor 300 to support various operations in accordance with examples as described herein. For example, the controller 302 may operate as a control unit of the processor 300, generating control signals that manage the operation of various components of the processor 300. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

[0077] The controller 302 may be configured to fetch (e.g., obtain, retrieve, receive) instructions from the memory 304 and determine subsequent instruction(s) to be executed to cause the processor 300 to support various operations in accordance with examples as described herein. The controller 302 may be configured to track memory address of instructions associated with the memory 304. The controller 302 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 302 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 300 to cause the processor 300 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 302 may be configured to manage flow of data within the processor 300. The controller 302 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 300.

[0078] The memory 304 may include one or more caches (e.g., memory local to or included in the processor 300 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 304 may reside within or on a processor chipset (e.g., local to the processor 300). In some other implementations, the memory 304 may reside external to the processor chipset (e.g., remote to the processor 300).

[0079] The memory 304 may store computer-readable, computer-executable code including instructions that, when executed by the processor 300, cause the processor 300 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 302 and/or the processor 300 may be configured to execute computer-readable instructions stored in the memory 304 to cause the processor 300 to perform various functions. For example, the processor 300 and/or the controller 302 may be coupled with or to the memory 304, the processor 300, the controller 302, and the memory 304 may be configured to perform various functions described herein. In some examples, the processor 300 may include multiple processors and the memory 304 may include multiple memories. One or more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

[0080] The one or more ALUs 306 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 306 may reside within or on a processor chipset (e.g., the processor 300). In some other implementations, the one or more ALUs 306 may reside external to the processor chipset (e.g., the processor 300). One or more ALUs 306 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 306 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 306 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 306 may support logical operations such as AND, OR,

exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 306 to handle conditional operations, comparisons, and bitwise operations.

[0081] Figure 4 illustrates an example of a NE 400 in accordance with aspects of the present disclosure. The NE 400 may include a processor 402, a memory 404, a controller 406, and a transceiver 408. The processor 402, the memory 404, the controller 406, or the transceiver 408, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g., operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

[0082] The processor 402, the memory 404, the controller 406, or the transceiver 408, or various combinations or components thereof may be implemented in hardware (e.g., circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

[0083] The processor 402 may include an intelligent hardware device (e.g., a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 402 may be configured to operate the memory 404. In some other implementations, the memory 404 may be integrated into the processor 402. The processor 402 may be configured to execute computer-readable instructions stored in the memory 404 to cause the NE 400 to perform various functions of the present disclosure.

[0084] The memory 404 may include volatile or non-volatile memory. The memory 404 may store computer-readable, computer-executable code including instructions when executed by the processor 402 cause the NE 400 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 404 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory

storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

[0085] In some implementations, the processor 402 and the memory 404 coupled with the processor 402 may be configured to cause the NE 400 to perform one or more of the functions described herein (e.g., executing, by the processor 402, instructions stored in the memory 404). For example, the processor 402 may support wireless communication at the NE 400 in accordance with examples as disclosed herein.

[0086] The controller 406 may manage input and output signals for the NE 400. The controller 406 may also manage peripherals not integrated into the NE 400. In some implementations, the controller 406 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 406 may be implemented as part of the processor 402.

[0087] In some implementations, the NE 400 may include at least one transceiver 408. In some other implementations, the NE 400 may have more than one transceiver 408. The transceiver 408 may represent a wireless transceiver. The transceiver 408 may include one or more receiver chains 410, one or more transmitter chains 412, or a combination thereof.

[0088] A receiver chain 410 may be configured to receive signals (e.g., control information, data, packets) over a wireless medium. For example, the receiver chain 410 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 410 may include at least one amplifier (e.g., a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 410 may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 410 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

[0089] A transmitter chain 412 may be configured to generate and transmit signals (e.g., control information, data, packets). The transmitter chain 412 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission

over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 412 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 412 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

[0090] Up to Release 18, the power adjustment state of SRS transmission can be the same as that of Physical Uplink Shared Channel (PUSCH) transmission or separate from that of PUSCH transmission. However, only one closed-loop power control adjustment state is supported for SRS power control separate from PUSCH. In Release 19 asymmetric DL sTRP/UL mTRP deployment scenarios, a UE may receive DL transmission from a macro gNB, but transmit UL signal to one or more micro nodes when coverage is limited to maximize UL throughput. The UE may still need to transmit SRS to the macro gNB, for example, SRS for DL CSI acquisition (i.e., SRS for antenna switching). In this scenario, the power adjustment state of SRS transmission to the macro gNB shall be separate from that of PUSCH transmission and shall be separate from that of SRS transmission to micro nodes as well since the transmission power of SRS transmission to the macro gNB and that to the micro nodes may be significantly different and the transmission powers shall be adjusted separately. Therefore, there is a need for supporting two closed-loop power control (PC) adjustment states for SRS transmission separate from PUSCH transmission for the scenario described above.

[0091] When two closed-loop power control adjustment states separate from PUSCH are configured for SRS transmission, some relevant issues need to be resolved. For example, how to indicate the Transmit Power Control (TPC) command for each separate closed loop shall be determined since Release 18 DCI format 2_3 is used to indicate TPC commands for SRS transmission with only one separate power control adjustment state. Besides, the SRS PC shall be enhanced such that power adjustment of SRS configured with two separate closed loops from PUSCH shall be calculated per closed loop power control adjustment

state. In this disclosure, methods to resolve the issues on two closed-loop power control adjustment states separate from PUSCH configured for SRS transmission are proposed.

[0092] In the present Technical Specifications (TS) of the Third Generation Partnership Project (3GPP), the following are provided.

7.3.1 UE behaviour in TS 38.213

- For the SRS power control adjustment state for active UL BWP b of carrier f of serving cell c and SRS transmission occasion i

- $h_{b,f,c}(i, l) = f_{b,f,c}(i, l)$, where $f_{b,f,c}(i, l)$ is the current PUSCH power control adjustment state as described in clause 7.1.1, if srs-PowerControlAdjustmentStates indicates a same power control adjustment state for SRS transmissions and PUSCH transmissions; or

- $$h_{b,f,c}(i) = h_{b,f,c}(i - i_0) + \sum_{m=0}^{C(S_i)-1} \delta_{\text{SRS},b,f,c}(m)$$
 if the UE is not configured for PUSCH

transmissions on active UL BWP b of carrier f of serving cell c , or if srs-

PowerControlAdjustmentStates indicates separate power control adjustment states between SRS transmissions and PUSCH transmissions, and if tpc-Accumulation is not provided, where

- The $\delta_{\text{SRS},b,f,c}$ values are given in Table 7.1.1-1

- $\delta_{\text{SRS},b,f,c}(m)$ is jointly coded with other TPC commands in a PDCCH with DCI format 2_3, as described in clause 11.4

- $\sum_{m=0}^{C(S_i)-1} \delta_{\text{SRS},b,f,c}(m)$ is a sum of TPC command values in a set S_i of TPC command values with cardinality $C(S_i)$ that the UE receives between $K_{\text{SRS}}(i - i_0) - 1$ symbols before SRS transmission occasion $i - i_0$ and $K_{\text{SRS}}(i)$ symbols before SRS transmission occasion i on active UL BWP b of carrier f of serving cell c for SRS power control adjustment state, where $i_0 > 0$ is the smallest integer for which $K_{\text{SRS}}(i)$ symbols before SRS transmission occasion $i - i_0$ is earlier than $K_{\text{SRS}}(i - i_0)$ symbols before SRS transmission occasion i

- if the SRS transmission is aperiodic, $K_{\text{SRS}}(i)$ is a number of symbols for active UL BWP b of carrier f of serving cell c after a last symbol of a corresponding PDCCH triggering the SRS transmission and before a first symbol of the SRS transmission

- if the SRS transmission is semi-persistent or periodic, $K_{\text{SRS}}(i)$ is a number of $K_{\text{SRS},\text{min}}$ symbols equal to the product of a number of symbols per slot, $N_{\text{ymb}}^{\text{slot}}$, and the minimum of the values provided by k_2 in PUSCH-ConfigCommon for active UL BWP b of carrier f of serving cell c

- If the first symbol of the SRS transmission occasion occurs within $T_{\text{proc},2}$ after a last symbol of a CORESET where the UE detects the DCI format providing the TPC command, the UE may postpone the application of the TPC until the above condition is not valid. $T_{\text{proc},2}$ is the PUSCH preparation time for the corresponding UE processing capability [6, TS 38.214] assuming $d_{2,1} = 0$, and μ corresponds to the smallest SCS configuration between the SCS configuration of the PDCCH carrying the DCI format and the SCS configuration of the SRS.
- If the UE has reached maximum power for active UL BWP b of carrier f of serving cell c at SRS transmission occasion $i - i_0$ and $\sum_{m=0}^{C(S_i)-1} \delta_{\text{SRS},b,f,c}(m) \geq 0$, then $h_{b,f,c}(i) = h_{b,f,c}(i - i_0)$
- If UE has reached minimum power for active UL BWP b of carrier f of serving cell c at SRS transmission occasion $i - i_0$ and $\sum_{m=0}^{C(S_i)-1} \delta_{\text{SRS},b,f,c}(m) \leq 0$, then $h_{b,f,c}(i) = h_{b,f,c}(i - i_0)$
- If a configuration for a $P_{\text{O_SRS},b,f,c}(q_s)$ value or for a $\alpha_{\text{SRS},b,f,c}(q_s)$ value for a corresponding SRS power control adjustment state l for active UL BWP b of carrier f of serving cell c is provided by higher layers
- $h_{b,f,c}(k) = 0, k = 0, 1, \dots, i$
- else
- $h_{b,f,c}(0) = \Delta P_{\text{rampup},b,f,c} + \delta_{b,f,c}$

where

$\delta_{b,f,c}$ is

- the TPC command value indicated in the random access response grant corresponding to a PRACH transmission according to Type-1 random access procedure, or in a random access response grant corresponding to MsgA transmissions according to Type-2 random access procedure with RAR message(s) for fallbackRAR, or
- the TPC command value indicated in a successRAR corresponding to MsgA transmissions for Type-2 random access procedure,

and

$$\Delta P_{\text{rampup},b,f,c} = \min \left[\max \left(0, P_{\text{C_MAX},f,c} - \left(P_{\text{O_SRS},b,f,c}(q_s) + 10 \log_{10} \left(2^{\mu} \cdot M_{\text{SRS},b,f,c}(i) \right) + \alpha_{\text{SRS},b,f,c}(q_s) \cdot PL_{b,f,c}(q_d) \right) \right), \Delta P_{\text{rampup_requested},b,f,c} \right];$$

where $\Delta P_{\text{rampup_requested},b,f,c}$ is provided by higher layers and corresponds to the total power ramp-up requested by higher layers from the first to the last preamble for active UL BWP b of carrier f of serving cell c .

- $h_{b,f,c}(i) = \delta_{\text{SRS},b,f,c}(i)$ if the UE is not configured for PUSCH transmissions on active UL BWP b of carrier f of serving cell c , or if srs-PowerControlAdjustmentStates indicates separate power control adjustment states between SRS transmissions and PUSCH transmissions, and tpc-Accumulation is provided, and the UE detects a DCI format 2_3 $K_{\text{SRS,min}}$ symbols before a first symbol of SRS transmission occasion i , where absolute values of $\delta_{\text{SRS},b,f,c}$ are provided in Table 7.1.1-1.

7.3.1.3.4 Format 2_3 in TS 38.212

DCI format 2_3 is used for the transmission of a group of TPC commands for SRS transmissions by one or more UEs. Along with a TPC command, an SRS request may also be transmitted.

The following information is transmitted by means of the DCI format 2_3 with CRC scrambled by TPC-SRS-RNTI:

- block number 1, block number 2, ..., block number B

where the starting position of a block is determined by the parameter startingBitOfFormat2-3 or startingBitOfFormat2-3SUL-v1530 provided by higher layers for the UE configured with the block.

If the UE is configured with higher layer parameter srs-TPC-PDCCH-Group = typeA for an UL without PUCCH and PUSCH or an UL on which the SRS power control is not tied with PUSCH power control, one block is configured for the UE by higher layers, with the following fields defined for the block:

- SRS request – 0 or 2 bits. The presence of this field is according to the definition in Clause 11.4 of [5, TS38.213]. If present, this field is interpreted as defined by Table 7.3.1.1.2-24.
- TPC command number 1, TPC command number 2, ..., TPC command number N , where each TPC command applies to a respective UL carrier provided by higher layer parameter cc-IndexInOneCC-Set

If the UE is configured with higher layer parameter srs-TPC-PDCCH-Group = typeB for an UL without PUCCH and PUSCH or an UL on which the SRS power control is not tied with PUSCH power control, one block or more blocks is configured for the UE by higher layers where each block applies to an UL carrier, with the following fields defined for each block:

- SRS request – 0 or 2 bits. The presence of this field is according to the definition in Clause 11.4 of [5, TS38.213]. If present, this field is interpreted as defined by Table 7.3.1.1.2-24.
- TPC command – 2 bits

The number of information bits in format 2_3 shall be equal to or less than the payload size of format 1_0 monitored in common search space in the same serving cell. If the number of information bits in format 2_3 is less than the payload size of format 1_0 monitored in common search space in the same serving cell, zeros shall be appended to format 2_3 until the payload size equals that of format 1_0 monitored in common search space in the same serving cell.

[0093] Figure 5 illustrates an example of UE transmitting UL signal to a micro node but receiving DL signal from a macro gNB in accordance with aspects of the present disclosure. In this asymmetric DL sTRP/UL mTRP deployment scenario, the UE 104 transmits UL signals (e.g., PUSCH or PUCCH transmission) to the micro node 102B but receives DL signals from the macro gNB 102A. The UE 104 may transmit one or more SRS resource sets, SRS resource set 1 502 for example, for beam management to the micro node 102B, and the SRS resource set 1 502 is configured with separate closed loop power control adjustment state from PUSCH transmission. The UE 104 may also be configured to transmit one or more SRS resource sets, SRS resource set 2 504 for example, for antenna switching for DL CSI acquisition to the macro gNB 102A, and the SRS resource set 2 504 is also configured as separate closed loop power control adjustment state since there is no PUSCH transmission to the macro gNB 102A.

[0094] SRS resource set 1 502 and SRS resource set 2 504 shall be configured with different closed loop power control adjustment states since the transmit power of SRS transmission to the macro gNB 102A and that to micro nodes 102B may be significantly different.

[0095] That is, in the asymmetric DL sTRP/UL mTRP deployment scenario, a UE may receive a Radio Resource Control (RRC) configuration of two separate closed loop power control adjustment states for Sounding Reference Signal (SRS) transmissions; receive Downlink Control Information (DCI) indicating Transmit Power Control (TPC) command for an SRS transmission configured with one of the separate closed loop power control adjustment states; and determine transmission power for the SRS transmission based on its separate closed loop power control adjustment state.

[0096] Throughout the disclosure, the phrase “two separate closed loop power control adjustment states for SRS transmissions” refers to the two closed loop power control adjustment states for SRS transmissions, or TPC loops, or closed loop indexes, that are both separate from the closed loop power control adjustment state for PUSCH transmission.

Configuring a second separate closed loop for SRS transmission

[0097] As a second closed loop PC adjustment state for SRS transmission is introduced, the number of separate SRS power control adjustment states maintained by the UE is doubled (i.e. from one to two) and the complexity will be increased. Therefore, a new UE capability shall be introduced to indicate whether the UE supports two different TPC loops for SRS closed loop power control separate from PUSCH transmission.

[0098] In Release 15, the power control adjustment state is configured per SRS resource set. If a UE supports two different separate TPC loops for SRS closed loop power control, a RRC parameter can be configured to indicate which closed loop power control state is used for an SRS resource set.

[0099] The following provides an example of configuring which one of the closed loop power control states being used for an SRS resource set. In this example, a new *separateClosedLoop1* is introduced for *srs-PowerControlAdjustmentStates* of the *SRS-ResourceSet*.

```
SRS-ResourceSet ::= SEQUENCE {
    srs-ResourceSetId      SRS-ResourceSetId,
    srs-ResourceIdList     SEQUENCE (SIZE(1..maxNrofSRS-ResourcesPerSet)) OF SRS-
    ResourceId OPTIONAL, -- Cond Setup
    ...
    srs-PowerControlAdjustmentStates ENUMERATED {sameAsFci2, separateClosedLoop,
    separateClosedLoop1}
    ...
}
```

[0100] In unified TCI framework, if the SRS resource set follows the unified TCI state, SRS power control adjustment state *l* is provided by *p0AlphaSetforSRS* associated with the indicated TCI-State or TCI-UL-State; and if the SRS resource set does not follow the unified TCI state, SRS power control adjustment state *l* is provided by *p0AlphaSetforSRS* associated with *TCI-State* or *TCI-UL-State* of an SRS resource with lowest *SRS-ResourceId* in the given set. To support two separate TPC loops for SRS closed loop power control, a RRC parameter can be configured in SRS resource set to indicate whether the same or

separate closed loop power control is used. The corresponding *p0AlphaSetforSRS* further provides the power control adjustment state *l*. Another method is the same or separate closed loop PC for an SRS transmission from PUSCH may be configured in *p0AlphaSetforSRS* directly. If the SRS resource set follows the unified TCI state, separate or same power control adjustment state is provided by *p0AlphaSetforSRS* associated with the indicated TCI-State or TCI-UL-State of an SRS resource with lowest *SRS-ResourceId* in the given set.

[0101] The following provides an example of configuring closed loop power control state in unified TCI framework. In this example, the *P0AlphaSet-r17* includes a new field *srs-PowerControlStates* for indicating the SRS power control states as *sameClosedLoop*, or *separateClosedLoop*. If the *separateClosedLoop* is configured and *closedLoopIndex-r17* is set *i0*, the first separate closed loop PC state is used for the SRS transmission; and if the *separateClosedLoop* is configured and *closedLoopIndex-r17* is set *i1*, the second closed loop PC state is used for the SRS transmission.

```

P0AlphaSet-r17 ::= SEQUENCE {
    p0-r17          INTEGER (-16..15) OPTIONAL, -- Need R
    alpha-r17 Alpha OPTIONAL, -- Need R
    closedLoopIndex-r17 ENUMERATED { i0, i1 }
    srs-PowerControlStates ENUMERATED { sameClosedLoop, separateClosedLoop }
}

```

Indicating TPC command for SRS supporting two separate closed loop power control states

[0102] DCI format 2_3 is used for the transmission of a group of TPC commands for SRS transmissions by one or more UEs. Along with a TPC command, an SRS request may also be transmitted. But up to Release 18, there is only one separate power control adjustment state for SRS transmission, so the TPC command indicated to a UE is definitely for the one separate closed loop SRS power control adjustment state. If two separate closed loop power control states are configured for SRS transmission, the following issues need to be resolved: how to indicate TPC command for SRS transmission for each separate closed loop power control state, and how a UE knows that the TPC command is applied for SRS transmission with which closed loop power control state. The following schemes are provided.

Scheme 1: Using a DCI format 2_3 to indicate TPC command for SRS transmission for a closed loop power control adjustment state

[0103] In this scheme, a DCI format 2_3 can indicate TPC command for an SRS transmission with one of the two separate closed loop power control adjustment states at one time. Different DCIs with format 2_3 shall be transmitted to adjust the power of SRS transmissions with different separate closed loop power control adjustment states.

[0104] In some embodiments, a new field indicating the closed loop index is added in each block in DCI format 2_3.

[0105] A new field, for example a closed loop indicator field, is added in a block to indicate which one of the separate closed loop power control adjustment states the corresponding TPC command is associated with, if the target UE is configured with two separate closed loop power control adjustment states for SRS. And each TPC command in the block in DCI format 2_3 is only applied to the SRS transmissions with the closed loop index as indicated by the new field.

[0106] Specifically, for TPC type A, the following fields are defined for a block:

- Closed loop indicator – 0 or 1 bit. 1 bit if SRS resource sets are configured with two different separate closed loop power control states in at least one UL carrier provided by higher layer parameter *cc-IndexInOneCC-Set*; 0 bit otherwise;
- SRS request – 0 or 2 bits. The presence of this field is according to the definition in Clause 11.4 of [5, TS38.213]. If present, this field is interpreted as defined by Table 7.3.1.1.2-24 of TS38.212.
- TPC command number 1, TPC command number 2, ..., TPC command number *N*, where each TPC command applies to SRS transmissions with closed loop index as indicated by Closed loop indicator field in a respective UL carrier provided by higher layer parameter *cc-IndexInOneCC-Set*. If all of the SRS sets are not configured with the indicated closed loop index in a UL carrier in *cc-IndexInOneCC-Set*, the corresponding TPC command is ignored.

[0107] A copy of Table 7.3.1.1.2-24 from TS38.212 of the current 3GPP specification Release 18 is reproduced as follows:

Table 7.3.1.1.2-24: SRS request

Value of SRS request field	Triggered aperiodic SRS resource set(s) for DCI format 0_1, 0_2, 1_1, 1_2, and 2_3 configured with higher layer parameter srs-TPC-PDCCH-Group set to 'typeB'	Triggered aperiodic SRS resource set(s) for DCI format 2_3 configured with higher layer parameter srs-TPC-PDCCH-Group set to 'typeA'
00	No aperiodic SRS resource set triggered	No aperiodic SRS resource set triggered
01	SRS resource set(s) configured by SRS-ResourceSet with higher layer parameter aperiodicSRS-ResourceTrigger set to 1 or an entry in aperiodicSRS-ResourceTriggerList set to 1 SRS resource set(s) configured by SRS-PosResourceSet with an entry in aperiodicSRS-ResourceTriggerList set to 1 when triggered by DCI formats 0_1, 0_2, 1_1, and 1_2	SRS resource set(s) configured with higher layer parameter usage in SRS-ResourceSet set to 'antennaSwitching' and resourceType in SRS-ResourceSet set to 'aperiodic' for a 1 st set of serving cells configured by higher layers
10	SRS resource set(s) configured by SRS-ResourceSet with higher layer parameter aperiodicSRS-ResourceTrigger set to 2 or an entry in aperiodicSRS-ResourceTriggerList set to 2 SRS resource set(s) configured by SRS-PosResourceSet with an entry in aperiodicSRS-ResourceTriggerList set to 2 when triggered by DCI formats 0_1, 0_2, 1_1, and 1_2	SRS resource set(s) configured with higher layer parameter usage in SRS-ResourceSet set to 'antennaSwitching' and resourceType in SRS-ResourceSet set to 'aperiodic' for a 2 nd set of serving cells configured by higher layers
11	SRS resource set(s) configured by SRS-ResourceSet with higher layer parameter aperiodicSRS-ResourceTrigger set to 3 or an entry in aperiodicSRS-ResourceTriggerList set to 3 SRS resource set(s) configured by SRS-PosResourceSet with an entry in aperiodicSRS-ResourceTriggerList set to 3 when triggered by DCI formats 0_1, 0_2, 1_1, and 1_2	SRS resource set(s) configured with higher layer parameter usage in SRS-ResourceSet set to 'antennaSwitching' and resourceType in SRS-ResourceSet set to 'aperiodic' for a 3 rd set of serving cells configured by higher layers

[0108] For TPC type B, the following fields are defined for each block:

- Closed loop indicator – 0 or 1 bit. 1 bit if SRS resource sets are configured with two different separate closed loop power control states; 0 bit otherwise;
- SRS request – 0 or 2 bits. The presence of this field is according to the definition in Clause 11.4 of [5, TS38.213]. If present, this field is interpreted as defined by Table 7.3.1.1.2-24 of TS38.212.

- TPC command –2 bits. TPC command applies to SRS transmissions with closed loop index as indicated by Closed loop indicator.

[0109] In some other embodiments, DCI format 2_3 with CRC scrambled with different *TPC-SRS-RNTIs* are used for the transmission of a group of TPC commands for SRS transmissions with different closed loop PC power control states.

[0110] In the embodiments, another *TPC-SRS-RNTI* (e.g., *eTPC-SRS-RNTI* in addition to the existing *TPC-SRS-RNTI*) is introduced or configured if SRS resource sets are configured with two different separate closed loop power control states from PUSCH transmission. DCI format 2_3 with CRC scrambled with different *TPC-SRS-RNTIs* are used for TPC commands indication for SRS transmissions with different closed loop PC state respectively.

[0111] For example, DCI format 2_3 with CRC scrambled with *TPC-SRS-RNTI* is used for TPC commands indication for SRS transmissions with separate closed loop PC state 0; DCI format 2_3 with CRC scrambled with *eTPC-SRS-RNTI* is used for TPC commands indication for SRS transmissions with separate closed loop PC state 1.

Scheme 2: Using a DCI format 2_3 to indicate TPC commands for SRS transmissions with different closed loop power control states simultaneously

[0112] In a first approach, two consecutive blocks in DCI format 2_3 are used for indicating TPC commands for SRS transmissions with each block indicating TPC command for SRS transmission with each closed loop power control state.

[0113] In the embodiments, two consecutive blocks are configured for a UE supporting two separate TPC loops for SRS and the starting position of a first block is determined by the parameter *startingBitOfFormat2-3* or *startingBitOfFormat2-3SUL-v1530* provided by higher layers for the UE configured with the block. Each block is used for indicating TPC commands for SRS transmissions with each closed loop PC state. Following two options are provided to associate a block with a separate closed loop PC state.

[0114] In a first option, each block is fixedly associated with a separate closed loop PC state and the TPC command in the block is only applied to the SRS transmission with the corresponding separate closed loop PC state. For example, the first block of the two

consecutive blocks is used for indicating TPC command for SRS transmissions with the separate closed loop power control state 0, and the second block is used for indicating TPC command for SRS transmissions with separate closed loop state 1.

[0115] In a first example (Example 1), DCI format 2_3 is used for the transmission of a group of TPC commands for SRS transmissions by one or more UEs. The following information is transmitted by means of the DCI format 2_3 with CRC scrambled by *TPC-SRS-RNTI*:

- block number 1, block number 2, ..., block number *B*

where the starting position of a block is determined by the parameter *startingBitOfFormat2-3* or *startingBitOfFormat2-3SUL-v1530* provided by higher layers for the UE configured with the block.

[0116] A UE #1 supports one separate TPC closed loop state and a UE #2 supports two separate TPC closed loop states. The starting positions indicate that block number 1 and block number 2 are used for indicating TPC commands for SRS for UE#1 and UE #2, respectively. For UE #2, block number 2 and block number 3 (i.e., two consecutive blocks) are used for indicating TPC commands for SRS transmission; where the block 2 (i.e., the first block) is used for indicating TPC commands for SRS transmission with separate closed loop PC state 0, and block 3 (i.e., the second block) is used for indicating TPC commands for SRS transmission with separate closed loop PC state 1. Supposing the aperiodic SRS resource set in a serving cell is configured with different closed loop states as in Table 1 below and the PC type of SRS is type B, and supposing an SRS request field is present in DCI format 2_3, then if SRS request is “01” in block number 2, the SRS resource sets 1, 3, 4 are activated according to Table 7.3.1.1.2-24 in TS 38.212, and the TPC command in block number 2 will be applied to SRS transmission with separate closed loop PC state 0 (i.e., applied to SRS transmission according to SRS resource set 3); and if SRS request is “10” in block number 3, the SRS resource sets 2, 5, 6, 8 are activated, and the TPC command in block number 3 will be applied to SRS transmission with separate closed loop PC state 1 (i.e., applied to SRS transmission according to SRS resource set 5 and SRS resource set 8).

SRS resource set ID	srs-PowerControlAdjustmentStates	aperiodicSRS-
---------------------	----------------------------------	---------------

		ResourceTrigger
SRS resource set 1	sameAsFci2	1
SRS resource set 2	not configured (i.e., sameAsFci1)	2
SRS resource set 3	separateClosedLoop	1
SRS resource set 4	separateClosedLoop1	1
SRS resource set 5	separateClosedLoop1	2
SRS resource set 6	separateClosedLoop	2
SRS resource set 7	separateClosedLoop1	3
SRS resource set 8	separateClosedLoop1	2

Table 1 Closed loop PC states configurations for SRS in a serving cell

[0117] In a second option, if an SRS request is present, each block is associated with a separate closed loop PC state same as the configured PC state for SRS resource set triggered by the SRS request in the block. If more than one SRS resource sets are activated, all the activated SRS resource sets shall be configured with a same separate closed loop PC state.

[0118] In a second example (Example 2) with same assumptions as in Example 1, except that the aperiodic SRS resource set configurations in a serving cell are those show in Table 2, if SRS request is “01” in block number 2, the SRS resource sets 1, 3, and 4 are activated, and the TPC command in block number 2 will be applied to SRS transmission with separate closed loop PC state 0 (i.e., applied to SRS transmission according to SRS resource set 3 and SRS resource set 4) since the triggered SRS resource set 3 and 4 are configured with separate closed loop PC state 0; and if SRS request is “11” in block number 3, then SRS resource set 7 is activated, and the TPC command in block number 3 will be applied to SRS transmission with closed loop PC state 1 (i.e., applied to SRS transmission according to SRS resource set 5, SRS resource set 6 and SRS resource set 8) since the triggered SRS resource set 7 is configured with separate closed loop PC state 1.

SRS resource set ID	srs-PowerControlAdjustmentStates	aperiodicSRS-ResourceTrigger
SRS resource set 1	sameAsFci2	1
SRS resource set 2	not configured (i.e., sameAsFci1)	2

SRS resource set 3	separateClosedLoop	1
SRS resource set 4	separateClosedLoop	1
SRS resource set 5	separateClosedLoop1	2
SRS resource set 6	separateClosedLoop1	2
SRS resource set 7	separateClosedLoop1	3
SRS resource set 8	separateClosedLoop1	2

Table 2 Closed loop PC states configurations for SRS in a serving cell

[0119] In a second approach, a DCI format 2_3 is used to indicate TPC commands for SRS transmissions with different closed loop power control states in one block. For example, a block in DCI format 2_3 includes two groups of TPC commands for indicating the TPC command for SRS transmission if the target UE is configured with two separate closed loop power control adjustment states for SRS and each group of TPC commands is for SRS transmission with each separate closed loop power control state.

[0120] In the embodiments, the number of TPC commands in a block in DCI format 2_3 is doubled if a UE supports two separate TPC loops for SRS. Different groups of TPC commands are used for indicating TPC commands for SRS transmissions with different separate closed loop PC states. The two options of the first approach for associating a block with a separate closed loop PC state can be applied in the second approach as well for associating a group of TPC command with a separate closed loop PC state.

[0121] Specifically, for TPC type A, the following fields are defined for the block:

- SRS request – 0 or 2 bits. The presence of this field is according to the definition in Clause 11.4 of [5, TS38.213]. If present, this field is interpreted as defined by Table 7.3.1.1.2-24 of TS38.212.
- TPC command number 1, TPC command number 2, ..., TPC command number N , TPC command number $N+1$, TPC command number $N+2$, ..., TPC command number $2N$ where the first group of TPC commands includes the first N TPC command and each TPC command of the first N TPC commands applies to SRS transmissions with separate closed loop index 0, the second group of TPC commands includes the second N TPC command and each TPC command of the

second N TPC commands applies to SRS transmissions with separate closed loop index 1 in a respective UL carrier provided by higher layer parameter *cc-IndexInOneCC-Set*. If all of the SRS sets are not configured with the indicated closed loop index in a UL carrier in *cc-IndexInOneCC-Set*, the corresponding TPC command is ignored.

[0122] For TPC type B, the following fields are defined for each block:

- SRS request – 0 or 2 bits. The presence of this field is according to the definition in Clause 11.4 of [5, TS38.213]. If present, this field is interpreted as defined by Table 7.3.1.1.2-24 of TS38.212.
- TPC command – 2 bits.
- TPC command 2 – 2 bits.

where the first group of TPC command includes the TPC command and the TPC command applies to SRS transmissions with separate closed loop index 0, and the second group of TPC command includes the TPC command 2 and TPC command 2 applies to SRS transmissions with separate closed loop index 1.

Limited range of start bit of a block configured to a UE

[0123] In the current 3GPP specification, the start bit of a block *startingBitOfFormat2-3* configured to a UE can be an integer of from 1 to 31 in the configuration of SRS TPC command in TS 38.331 as illustrated below.

```
SRS-TPC-CommandConfig ::= SEQUENCE {
    startingBitOfFormat2-3  INTEGER (1..31) OPTIONAL, -- Need R
    fieldTypeFormat2-3     INTEGER (0..1) OPTIONAL, -- Need R
    ...
    [[startingBitOfFormat2-3SUL INTEGER (1..31) OPTIONAL -- Need R
]]
}
```

[0124] In Release 19, to indicate the TPC command for SRS transmission configured with two separate closed loop adjustment states, the size of each block in DCI format 2_3 may be increased, e.g., in the two schemes above. The start bit of a block in DCI format 2_3 may be limited in Release 19.

[0125] Taking SRS TPC type B as an example, if the SRS request is present, each block is 4 bits and up to 8 blocks can be included in DCI format 2_3 according to the current standard.

[0126] If a DCI format 2_3 is used to indicate TPC command for SRS for one of the two separate closed loop power control adjustment states at one time with a new field (i.e., closed loop indicator) added in each block, each block is 5 bits and up to 6 blocks can be included in a DCI format 2_3.

[0127] Further, if two consecutive blocks in DCI format 2_3 are used to indicate TPC command for SRS transmissions for a UE with each block indicating TPC command for SRS transmissions with each separate closed loop power control state, a DCI format 2_3 can transmit TPC commands for up to four UEs which is half of the number of UEs supported by the current standard. Besides, the payload size of DCI format 2_3 shall be aligned with DCI format 1_0 monitored in common search space in the same serving cell. Generally, the payload size of DCI format 1_0 may be larger than 31 bits.

[0128] Therefore, to keep flexibility, if two separate closed loop adjustment states are configured for SRS in a UL carrier, the range of start bit of a block may be extended to X bits where X is an integer larger than 31. For example, the start bit of a block *startingBitOfFormat2-3* configured to a UE may be an integer of from 1 to 62, or from 1 to 63.

SRS PC calculated per closed loop power control adjustment state

[0129] In TS 38.213, a UE determines the SRS transmission power $P_{\text{SRS},b,f,c}(i, q_s, l)$ in SRS transmission occasion i as

$$P_{\text{SRS},b,f,c}(i, q_s, l) = \min \left\{ P_{\text{CMAX},f,c}(i), P_{\text{O_SRS},b,f,c}(q_s) + 10 \log_{10} (2^{\mu} \cdot M_{\text{SRS},b,f,c}(i)) + \alpha_{\text{SRS},b,f,c}(q_s) \cdot PL_{b,f,c}(q_d) + h_{b,f,c}(i, l) \right\}$$

[dBm]

- where the closed loop PC term, $h_{b,f,c}(i) = h_{b,f,c}(i - i_0) + \sum_{m=0}^{C(S_i)-1} \delta_{\text{SRS},b,f,c}(m)$

if a UE is configured with separate power control adjustment states between SRS transmissions and PUSCH transmissions.

[0130] In Release 19, if two different separate closed loop PC adjustment states are configured for SRS transmissions, the $h_{b,f,c}(i)$ shall be calculated per separate power control adjustment state l .

[0131] Specifically, $h_{b,f,c}(i, l) = h_{b,f,c}(i - i_0, l) + \sum_{m=0}^{C(S_i)-1} \delta_{\text{SRS},b,f,c}(m, l)$ and if *tpc-Accumulation* is not provided, where

- The $\delta_{\text{SRS},b,f,c}$ values are given in Table 7.1.1-1 of TS38.213
- $\delta_{\text{SRS},b,f,c}(m, l)$ is jointly coded with other TPC commands in a PDCCH with DCI format 2_3, as described in clause 11.4
- $\sum_{m=0}^{C(S_i)-1} \delta_{\text{SRS},b,f,c}(m, l)$ is a sum of TPC command values in a set S_i of TPC command values with cardinality $C(S_i)$ that the UE receives between $K_{\text{SRS}}(i - i_0) - 1$ symbols before SRS transmission occasion $i - i_0$ and $K_{\text{SRS}}(i)$ symbols before SRS transmission occasion i on active UL BWP b of carrier f of serving cell c for SRS power control adjustment state l , where $i_0 > 0$ is the smallest integer for which $K_{\text{SRS}}(i)$ symbols before SRS transmission occasion $i - i_0$ is earlier than $K_{\text{SRS}}(i - i_0)$ symbols before SRS transmission occasion i
- If the UE has reached maximum power for active UL BWP b of carrier f of serving cell c at SRS transmission occasion $i - i_0$ and $\sum_{m=0}^{C(S_i)-1} \delta_{\text{SRS},b,f,c}(m, l) \geq 0$, then $h_{b,f,c}(i, l) = h_{b,f,c}(i - i_0, l)$
- If UE has reached minimum power for active UL BWP b of carrier f of serving cell c at SRS transmission occasion $i - i_0$ and $\sum_{m=0}^{C(S_i)-1} \delta_{\text{SRS},b,f,c}(m, l) \leq 0$, then $h_{b,f,c}(i, l) = h_{b,f,c}(i - i_0, l)$
- If a configuration for a $P_{\text{O_SRS},b,f,c}(q_s)$ value or for a $\alpha_{\text{SRS},b,f,c}(q_s)$ value for a corresponding SRS power control adjustment state l for active UL BWP b of carrier f of serving cell c is provided by higher layers
 - $h_{b,f,c}(k, l) = 0, k = 0, 1, \dots, i$
 - else
 - $h_{b,f,c}(0, l) = \Delta P_{\text{rampup},b,f,c} + \delta_{b,f,c}$

Where $l = 0$, and

$\delta_{b,f,c}$ is

- the TPC command value indicated in the random access response grant corresponding to a PRACH transmission according to Type-1 random access procedure, or in a random access response grant corresponding to MsgA transmissions according to Type-2 random access procedure with RAR message(s) for fallbackRAR, or
- the TPC command value indicated in a successRAR corresponding to MsgA transmissions for Type-2 random access procedure,

and

$$\Delta P_{\text{rampup},b,f,c} = \min \left[\max \left(0, P_{\text{CMAX},f,c} - \left(P_{\text{O_SRS},b,f,c}(q_s) + 10 \log_{10} \left(2^{\mu} \cdot M_{\text{SRS},b,f,c}(i) \right) + \alpha_{\text{SRS},b,f,c}(q_s) \cdot PL_{b,f,c}(q_d) \right) \right), \Delta P_{\text{rampup_requested},b,f,c} \right];$$

where $\Delta P_{\text{rampup_requested},b,f,c}$ is provided by higher layers and corresponds to the total power ramp-up requested by higher layers from the first to the last preamble for active UL BWP b of carrier f of serving cell c .

- $h_{b,f,c}(i,l) = \delta_{\text{SRS},b,f,c}(i,l)$ if *tpc-Accumulation* is provided, and the UE detects a DCI format 2_3 $K_{\text{SRS,min}}$ symbols before a first symbol of SRS transmission occasion i , where absolute values of $\delta_{\text{SRS},b,f,c}$ are provided in Table 7.1.1-1 of TS38.213.

[0132] Figure 6 illustrates a flowchart of a method in accordance with aspects of the present disclosure. The operations of the method may be implemented by a UE as described herein. In some implementations, the UE may execute a set of instructions to control the function elements of the UE to perform the described functions.

[0133] At 602, the method may include receiving a Radio Resource Control (RRC) configuration of two separate closed loop power control adjustment states for Sounding Reference Signal (SRS) transmissions. The operations of 602 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 602 may be performed by a UE as described with reference to Figure 2.

[0134] At 604, the method may include receiving Downlink Control Information (DCI) indicating Transmit Power Control (TPC) command for an SRS transmission configured with one of the separate closed loop power control adjustment states. The operations of 604 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 604 may be performed by a UE as described with reference to Figure 2.

[0135] At 606, the method may include determining transmission power for the SRS transmission based on its separate closed loop power control adjustment state. The operations of 606 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 606 may be performed by a UE as described with reference to Figure 2.

[0136] It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0137] Figure 7 illustrates a flowchart of a method in accordance with aspects of the present disclosure. The operations of the method may be implemented by a NE as described herein. In some implementations, the NE may execute a set of instructions to control the function elements of the NE to perform the described functions.

[0138] At 702, the method may include transmitting a Radio Resource Control (RRC) configuration of two separate closed loop power control adjustment states for Sounding Reference Signal (SRS) transmissions. The operations of 702 may be performed in accordance with examples as described herein. In some implementations, aspects of the operations of 702 may be performed by a NE as described with reference to Figure 4.

[0139] At 704, the method may include transmitting Downlink Control Information (DCI) indicating Transmit Power Control (TPC) command for an SRS transmission configured with one of the separate closed loop power control adjustment states. The operations of 704 may be performed in accordance with examples as described herein. In

some implementations, aspects of the operations of 704 may be performed by a NE as described with reference to Figure 4.

[0140] It should be noted that the method described herein describes a possible implementation, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible.

[0141] The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A user equipment (UE) for wireless communication, comprising:
 - at least one memory; and
 - at least one processor coupled with the at least one memory and configured to cause the UE to:
 - receive a Radio Resource Control (RRC) configuration of two separate closed loop power control adjustment states for Sounding Reference Signal (SRS) transmissions;
 - receive Downlink Control Information (DCI) indicating Transmit Power Control (TPC) command for an SRS transmission configured with one of the separate closed loop power control adjustment states; and
 - determine transmission power for the SRS transmission based on its separate closed loop power control adjustment state.
2. The UE of claim 1, wherein the DCI is DCI format 2_3 indicating TPC command for the SRS transmission with one of the separate closed loop power control adjustment states.
3. The UE of claim 2, wherein the DCI format 2_3 comprises a block configured to the UE that includes a field to indicate one of the separate closed loop power control adjustment states with which the TPC command of the block is associated.
4. The UE of claim 3, wherein, for TPC type A, the field is one bit where two separate closed loop power control adjustment states are configured for SRS transmissions in at least one Uplink (UL) carrier provided by higher layer parameter *cc-IndexInOneCC-Set*, and zero bit otherwise.

5. The UE of claim 3, wherein, for TPC type B, the field is one bit where two separate closed loop power control adjustment states are configured for SRS transmissions, and zero bit otherwise.
6. The UE of claim 2, wherein two Transmit Power Control - Sounding Reference Signal - Radio Network Temporary Identifiers (TPC-SRS-RNTIs) are configured by RRC.
7. The UE of claim 6, wherein the DCI format 2_3 with Cyclic Redundancy Check (CRC) scrambled with different TPC-SRS-RNTIs are used for the transmission of TPC commands for SRS transmissions with different closed loop PC power control states.
8. The UE of claim 1, wherein the DCI is DCI format 2_3 including TPC commands for SRS transmissions where different SRS transmissions are with different separate closed loop power control adjustment states.
9. The UE of claim 8, wherein two consecutive blocks in the DCI format 2_3 are used for indicating TPC commands for SRS transmissions, and each of the two consecutive blocks includes TPC command for SRS transmission with each of the two separate closed loop power control adjustment states.
10. The UE of claim 9, wherein the two consecutive blocks are fixedly associated with the two separate closed loop power control adjustment states in a one-to-one manner.
11. The UE of claim 9, wherein each one of the two consecutive blocks comprises an SRS request, and is associated with the closed loop power control adjustment state as the configured state for the SRS transmissions triggered by the SRS request.

12. The UE of claim 9, wherein a block in the DCI format 2_3 includes two groups of TPC commands with each group being for SRS transmission with each of the two separate closed loop power control adjustment states.

13. The UE of claim 1, wherein the DCI is DCI format 2_3 and start bit of a block is configured to a value of an integer larger than 31.

14. The UE of claim 1, wherein the transmission power for the SRS transmission is determined with an adjustment part calculated based on its separate closed loop power control adjustment state.

15. The UE of claim 1, wherein the separate closed loop power control adjustment state for the SRS transmission is configured in *p0AlphaSetforSRS*.

16. The UE of claim 1, wherein the separate closed loop power control adjustment state for the SRS transmission is configured in an SRS resource set.

17. The UE of claim 1, wherein the at least one processor is further configured to cause the UE to transmit a report that two separate closed loop power control adjustment states for SRS transmissions are supported.

18. A processor for wireless communication, comprising:

at least one controller coupled with at least one memory and configured to cause the processor to:

receive a Radio Resource Control (RRC) configuration of two separate closed loop power control adjustment states for Sounding Reference Signal (SRS) transmissions;

receive Downlink Control Information (DCI) indicating Transmit Power Control (TPC) command for an SRS transmission configured with one of the separate closed loop power control adjustment states; and

determine transmission power for the SRS transmission based on its separate closed loop power control adjustment state.

19. A method performed by a user equipment (UE), the method comprising:

receiving a Radio Resource Control (RRC) configuration of two separate closed loop power control adjustment states for Sounding Reference Signal (SRS) transmissions;

receiving Downlink Control Information (DCI) indicating Transmit Power Control (TPC) command for an SRS transmission configured with one of the separate closed loop power control adjustment states; and

determining transmission power for the SRS transmission based on its separate closed loop power control adjustment state.

20. A base station for wireless communication, comprising:

at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the base station to:

transmit a Radio Resource Control (RRC) configuration of two separate closed loop power control adjustment states for Sounding Reference Signal (SRS) transmissions; and

transmit Downlink Control Information (DCI) indicating Transmit Power Control (TPC) command for an SRS transmission configured with one of the separate closed loop power control adjustment states.