(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 January 2017 (19.01.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/008236 A1

(51) International Patent Classification: *H04B 7/04* (2006.01)

(21) International Application Number: PCT/CN2015/083946

(22) International Filing Date: 14 July 2015 (14.07.2015)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: METHOD AND APPARATUS FOR REFERENCE SIGNAL CONFIGURATION AND DETECTION

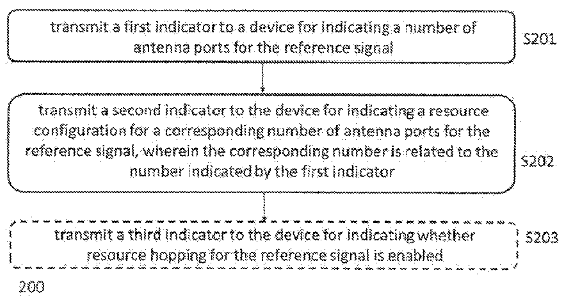

Fig. 2A

(57) **Abstract**: Embodiments of the present disclosure provide a method for configuring reference signal in a wireless system. The method comprises transmitting a first indicator to a device for indicating a number of antenna ports for the reference signal; and transmitting a second indicator to the device for indicating a resource configuration for a corresponding number of antenna ports for the reference signal, wherein the corresponding number is related to the number indicated by the first indicator; wherein the first indicator further indicates at least one of : a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal, whether the reference signal is beamformed or not; and part of information on a resource configuration for a predefined number of antenna ports for the reference signal; and/or the second indicator further indicates a resource hopping pattern for the indicated number of antenna ports for the reference signal. A method for signal detection according to the transmission pattern is also provided. Embodiments of the present disclosure also provide corresponding apparatus.

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METHOD AND APPARATUS FOR REFERENCE SIGNAL CONFIGURATION AND DETECTION

TECHNICAL FIELD

[0001] The non-limiting and exemplary embodiments of the present disclosure generally relate to the technical field of radio communications, and specifically to a method and apparatus for reference signal configuration and detection.

BACKGROUND

[0002] This section introduces aspects that may facilitate a better understanding of the disclosure. Accordingly, the statements of this section are to be read in this light and are not to be understood as admissions about what is in the prior art or what is not in the prior art.

[0003] Multiple Input and Multiple Output (MIMO) techniques have been known as an effective way for improving spectrum efficiency (SE) in wireless communication systems. For example, MIMO has been adopted as a key feature of Long Term Evolution (LTE)/LTE-Advanced (LTE-A) system developed by the third generation project partnership (3GPP). Conventional one-dimensional (horizontal domain) antenna array can provide flexible beam adaption in the azimuth domain only through the horizontal domain precoding process, wherein a fixed down-tilt is applied in the vertical direction. It has been found recently that full MIMO capability can be exploited through leveraging a two dimensional (2D) antenna planar such that a user-specific elevation beamforming and spatial multiplexing in the vertical domain are also possible.

[0004] 2D antenna array with larger number of transceiver Units (TxRUs) is introduced to enable full dimensional MIMO (FD-MIMO). In contrast to the conventional antenna system, a 2D antenna array allows more flexibility in vertical domain in addition to the horizontal domain freedom. In order to fully utilize the benefit of FD-MIMO, channel state information (CSI) measurement procedure is crucial and need to be carefully investigated.

[0005] CSI-RS is used for CSI measurement, and at the current stage, some candidate schemes for CSI-RS enhancement in 3GPP Rel-13 have been included in a 3GPP document TR 36.897, which mainly focuses on discussions related to beamformed CSI-RS schemes and non-precoded CSI-RS. It has been proposed that to facilitate 3D channel information measurement at a user equipment (UE) side, a CSI-RS should be transmitted from 8 or more antenna ports. Up to 16 antenna ports for transmitting a non-precoded CSI-RS is desired.

Regarding beamformed CSI-RS, it may reduce CSI-RS overhead and provide accurate and full dimensional CSI measurement for an antenna array with large number TxRUs.

[0006] A downlink MIMO transmission can be generally expresses as follows:

$$Y=HWs+v$$

where H is a MIMO channel, W is a precoding matrix for data transmission, s contains multiple user data streams and v stands for the interference plus noise. For 8 transmitters (TX) case, a MIMO precoder can be expressed as: W = W1*W2, and W1 = [X 0;0 X] which is block diagonal. The block diagonal W1 is used for matching the spatial covariance of dual-polarized antenna setup with any spacing (e.g. $\lambda/2$ or 4λ). At least sixteen 8Tx Discrete Fourier Transformation (DFT) vectors generated from W1 and co-phasing via W2 are used for matching the spatial covariance of ULA antenna setup. It may provide good performance for high and low spatial correlation. For rank 1 and 2 DL transmission, W1with Nb=4 can provide adjacent overlapping beams, and W2 can be used for further selection and co-phasing.

[0007] The beamformed CSI-RS-based scheme was proposed In a 3GPP document R1-153154 and R1-152684. eNB can configure one or more CSI-RS resources on a UE expected 3D beam. In an example shown in Fig. 1A, only 2- port CSI-RS per beam is needed for two polarizations. It has been discussed in 3GPP that multiple beams should be configured to UE as UE specific or cell specific RS. UE may choose one or multiple beams, and report CSI on chosen beam(s). Assuming the CSI-RS is beamformed using a 3D precoding vector $W_{CSI\text{-}RS}$ before transmission, then at the receiver side, the obtained signal can be expressed as:

$$\mathbf{y}_{\text{CSI-RS}} = \mathbf{H}\mathbf{W}_{\text{CSI-RS}}\mathbf{s}_{\text{CSI-RS}} + \mathbf{v}$$

where $\mathbf{s}_{\text{CSI-RS}}$ is the CSI_RS, and v is the the interference plus noise. By measurement of the beamformed CSI-RS, UE can achieve composite channel information. The UE may make a channel estimation of the equivalent channel $\mathbf{HW}_{\text{CSI-RS}}$ and derives the feedback information.

[0008] Also in the 3GPP document R1-152684, Multiple CSI-RS resources are transmitted on different vertical beams. As described in the Fig.1B, an eNB can configure one or more CSI-RS resources on UE expected vertical beams for CSI measurement. It has been discussed in 3GPP that multiple beams should be configured to UE as UE specific or cell specific RS. UE may choose one or multiple beams, and report CSI on chose beam(s). If the UE is configured with one beam in one CSI process, the CSI computation and feedback can be same as the legacy ones. Then the scheme can be eNB implementation issues.

[0009] The scheme of non-beamformed (or, non-precoded) CSI-RS was discussed in 3GPP documents R1-152483 and R1-151646. The non-precoded CSI-RS based scheme implies that one CSI-RS port can only mapped onto one transceiver unit (TxRU) without any virtualization. Under this scheme, full CSI-RS port measurement scheme is a natural extension from legacy CSI-RS ports measurement mechanism. Full CSI-RS port measurement and feedback scheme stands for the scheme that all the CSI-RS ports cover all the TxRUs in the one to one mapping manner so that full channel spatial information can be obtained. Given that, this scheme can achieve the optimal measurement performance as full freedom of antenna ports can be utilized and the full channel information can be measured. The principle for the new CSI-RS ports pattern (larger than 8 CSI-RS ports) design may consider constructing multiple existing CSI-RS port patterns. Non-precoded CSI-RS pattern design can consider a CSI-RS pattern design with CSI-RSs time divisionally multiplexed (TDMed) among different subframes, one PRB pair based CSI-RS pattern design, and a CSI-RS pattern design with CSI-RSs frequency divisionaly multiplexed (FDMed) among different PRB pairs.

[0010] Current CSI-RS configurations allow only up to 8 CSI-RS ports. The only way to configure more than 8 CSI-RS ports for a single UE is to configure multiple CSI processes with different CSI-RS configurations. While such an approach is possible, it lacks flexibility for efficient channel measurement of both horizontal and vertical directions. Another approach would be to configure multiple CSI-RS resources for a single CSI process. Instead of limiting the number of CSI-RS configurations within a CSI process to 1 as in Rel-12, the specification would allow multiple CSI-RS configurations for each CSI process. For example, it is possible to configure two or three CSI-RS resources with the number of CSI-RS ports < P1=8,P2=4 > or < P1=4,P2=4 ,P3=4> to support a 4 horizontal (H) 3 vertical (V) antenna array structure whose total number of TXRU is 12 as depicted in Fig. 1C. As shown in Fig. 1C, by configuring multiple CSI-RS resources, it is possible to secure both scalability (e.g. to support up to 64 CSI-RS ports) and flexibility (e.g. to support multiple of 2 CSI-RS ports).

SUMMARY

[0011] Various embodiments of the disclosure provide flexible transmission pattern configuration. Other features and advantages of embodiments of the disclosure will also be understood from the following description of specific embodiments when read in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of embodiments of the disclosure.

[0012] In a first aspect of the disclosure, there is provided a method for reference signal configuration in a multiple input multiple output system, the method comprises transmitting a first indicator to a device for indicating a number of antenna ports for the reference signal; and transmitting a second indicator to the device for indicating a resource configuration for a corresponding number of antenna ports for the reference signal, wherein the corresponding number is related to the number indicated by the first indicator; wherein the first indicator further indicates at least one of: a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal, whether the reference signal is beamformed or not; and part of information on a resource configuration for a predefined number of antenna ports for the reference signal; and/or, wherein the second indicator further indicates a resource hopping pattern for the indicated number of antenna ports for the reference signal.

[0013] In one embodiment, the first indicator may indicate the number of antenna ports for the reference signal by indicating an element in a predefined set, and wherein at least two elements in the predefined set may indicate a same number of antenna ports and different numbers of horizontal antenna ports. In another embodiment, the first indicator may indicate the number of antenna ports for the reference signal by indicating an element in a predefined set, and wherein at least one element in the predefined set may indicate that the reference signal is beamformed. In still another embodiment, the at least one elements in the predefined set may further indicate implicitly a predefined number of beams and a predefined number of antenna ports for the reference signal.

[0014] In an embodiment, the first indicator may indicate the number of antenna ports for the reference signal by jointly indicating the number of antenna ports for the reference signal together with the second indicator.

[0015] In another embodiment, the first indicator may indicate part of information on a resource configuration for a predefined number of antenna ports for the reference signal by jointly indicating the resource configuration for the corresponding number of antenna ports for the reference signal together with the second indicator, and wherein when the first indicator indicate a first predefined number of antenna ports, the second indicator may indicate a resource configuration for a second predefined number of antenna ports which is different from the first predefined number of antenna ports.

[0016] In one embodiment, the second indicator may indicate the resource configuration by indicating a resource configuration for N antenna ports from a predefined configuration set, which includes part but not all configuration candidates formed by combining L resource configurations for K antenna ports, and wherein N=LxK and N, L and K are all positive integers. In another embodiment, at least two configuration candidates in the predefined configuration set may indicate partly overlapped resources for the N antenna ports.

[0017] In one embodiment, the second indicator may indicate the resource configuration by indicating a resource configuration for the corresponding number of antenna ports from a predefined configuration set, and at least one configuration candidates in the predefined configuration set may indicate a predefined resource hopping pattern for the corresponding number of antenna ports. In another embodiment, the predefined resource hopping pattern may indicate resource change for at least part of the corresponding number of antenna ports in different physical resource blocks or different subframes. In one further embodiment, the predefined resource hopping pattern may indicate the resource change for the at least part of the corresponding number of antenna ports in different physical resource blocks or different subframes on a per-beam basis.

[0018] In one embodiment, the method may further comprise transmitting a third indicator to the device for indicating whether resource hopping for the reference signal is enabled.

[0019] In a second aspect of the disclosure, there is provided a method for reference signal detection in a multiple input multiple output system, the method comprises receiving, from a base station, a first indicator for indicating a number of antenna ports for the reference signal; and receiving from the base station a second indicator for indicating a resource configuration for a corresponding number of antenna ports for the reference signal; and detecting the reference signal based on the received first indicator and the received second indicator; wherein the first indicator further indicates at least one of: a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal, whether the reference signal is beamformed or not; and part of information on a resource configuration for a predefined number of antenna ports for the reference signal, and/or, wherein the second indicator further indicates a resource hopping pattern for the indicated number of antenna ports for the reference signal.

[0020] In one embodiment, the method may further comprise receiving, from the base station, a third indicator for indicating whether resource hopping for the reference signal is enabled, and wherein detecting the reference signal based on the received first indicator and the received second indicator comprises detecting the reference signal also based on the received third indicator.

[0021] In a third aspect of the disclosure, there is provided an apparatus for reference signal configuration in a multiple input multiple output system, the apparatus comprises a first transmitting unit, configured to transmit a first indicator to a device for indicating a number of antenna ports for the reference signal; and a second transmitting unit, configured to transmit a second indicator to the device for indicating a resource configuration for a corresponding number of antenna ports for the reference signal, wherein the corresponding number is related to the number indicated by the first indicator; wherein the first indicator further indicates at least one of: a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal, whether the reference signal is beamformed or not; and part of information on a resource configuration for a predefined number of antenna ports for the reference signal; and/or, wherein the second indicator further indicates a resource hopping pattern for the indicated number of antenna ports for the reference signal.

[0022] In a fourth aspect of the disclosure, there is provided an apparatus for reference signal detection in a multiple input multiple output system, the apparatus comprises a first receiving unit, configured to receive, from a base station, a first indicator for indicating a number of antenna ports for the reference signal; and a second receiving unit, configured to receive from the base station a second indicator for indicating a resource configuration for a corresponding number of antenna ports for the reference signal; and a detection unit, configured to detect the reference signal based on the received first indicator and the received second indicator; wherein the first indicator further indicates at least one of: a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal, whether the reference signal is beamformed or not; and part of information on a resource configuration for a predefined number of antenna ports for the reference signal; and/or, wherein the second indicator further indicates a resource hopping pattern for the indicated number of antenna ports for the reference signal.

[0023] In one embodiment, the apparatus may further comprise a third receiving unit, configured to receive, from the base station, a third indicator for indicating whether resource hopping for the reference signal is enabled, and wherein the detection unit is further configured to detect the reference signal also based on the received third indicator.

[0024] In a fifth aspect of the disclosure, there is provided an apparatus for reference signal configuration. The apparatus comprises a processor and a memory, said memory containing instructions executable by said processor whereby said apparatus is operative to perform any method in accordance with the first aspect of the disclosure.

[0025] In a sixth aspect of the disclosure, there is provided an apparatus for downlink reference signal detection. The apparatus comprises a processor and a memory, said memory containing instructions executable by said processor whereby said apparatus is operative to perform any method in accordance with the second aspect of the disclosure.

[0026] According to the various aspects and embodiments as mentioned above, a base station can configure CSI-RS flexibly and efficiently, and inform the configuration to UEs to enable proper detection.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The above and other aspects, features, and benefits of various embodiments of the disclosure will become more fully apparent, by way of example, from the following detailed description with reference to the accompanying drawings, in which like reference numerals or letters are used to designate like or equivalent elements. The drawings are illustrated for facilitating better understanding of the embodiments of the disclosure and not necessarily drawn to scale, in which:

[0028] Figs. 1A-1C illustrate schematically 3D beamforming, vertical beamforming and non-precoded CSI-RS, respectively;

[0029] Fig. 1D illustrates an exemplary wireless system where embodiments of the present invention may be implemented;

[0030] Fig. 2A illustrates an exemplary flowchart of a method for a reference signal configuration according to an embodiment of the present disclosure;

[0031] Fig. 2B illustrates an example for indicating number of antennas in vertical domain and horizontal domain respectively;

[0032] Fig. 3A shows an example of obtaining 12-port CSI-RS configuration by combining a 8-port CSI-RS and a 4-port CSI-RS;

[0033] Fig. 3B shows an example of configuring a 16-port CSI-RS resource configuration for a 12-port CSI-RS;

[0034] Figs. 3C-3D illustrate schematically power boosting for a CSI-RS antenna port in slot 0 and slot 1, respectively, with the CSI-RS resource configuration shown in Fig. 3B;

[0035] Fig. 4A illustrate schematically an undesired way for obtaining a 16-port CSI resource configuration by combining two 8-port CSI-RS configurations far from each other;

[0036] Fig. 4B illustrate schematically 10 resource configuration candidates for a 4-port CSI-RS;

[0037] Fig. 4C illustrate schematically 10 overlapping resource configuration candidates for a 12-port CSI-RS and a 16-port CSI-RS by combining contiguous 4-port CSI-RS configurations;

[0038] Figs. 5A-5B illustrate examples of resource hopping for vertically beamformed CSI-RS and 3D beamformed CSI-RS respectively;

[0039] Fig. 6A illustrates an exemplary procedure for implementing CSI-RS hopping;

[0040] Fig. 6B illustrates an example of inter-group resource hopping for CSI-RS in different subframes;

[0041] Fig. 6C illustrates an example of inter-set resource hopping for CSI-RS in different subframes;

[0042] Fig. 6D illustrates an example of inter-group resource hopping for CSI-RS in different physical resource blocks (PRBs);

[0043] Fig. 7 illustrates an exemplary flowchart of a method for a reference signal detection according to an embodiment of the present disclosure;

[0044] Figs. 8A-8E illustrate exemplary flowcharts of a method for a reference signal configuration according to an embodiment of the present disclosure;

[0045] Fig. 9 illustrates a schematic block diagram of an apparatus in a wireless system for configuring reference signals according to an embodiment of the present disclosure;

[0046] Fig. 10 illustrates a schematic block diagram of an apparatus for reference signal detection, according to an embodiment of the present disclosure; and

[0047] Fig. 11 illustrates a simplified block diagram of apparatus that are suitable for use in practicing the embodiments of the present disclosure.

DETAILED DESCRIPTION

[0048] Hereinafter, the principle and spirit of the present disclosure will be described with reference to the illustrative embodiments. It should be understood, all these embodiments are given merely for the skilled in the art to better understand and further practice the present disclosure, but not for limiting the scope of the present disclosure. For example, features illustrated or described as part of one embodiment may be used with another embodiment to yield still a further embodiment. In the interest of clarity, not all features of an actual implementation are described in this specification.

[0049] References in the specification to “one embodiment”, “an embodiment”, “an example embodiment” etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is associated with the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0050] It shall be understood that, although the terms “first” and ”second” etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and similarly, a second element could be termed a first element, without departing from the scope of example embodiments. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed terms.

[0051] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be liming of example embodiments. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising", "has", "having", "includes" and/or "including", when used herein, specify the presence of stated features, elements, and/or components etc., but do not preclude the presence or addition of one or more other features, elements, components and/ or combinations thereof.

[0052] In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. For example, the term device used herein may refer to any terminal having wireless communication capabilities or user equipment (UE), including but not limited to, mobile phone, cellular phones, smart phone, or personal digital assistants (PDAs), portable computers, image capture device such as digital cameras, gaming devices, music storage and playback appliances, wearable devices and any portable units or terminals that have wireless communication capabilities, or Internet appliances permitting wireless Internet access and browsing and the like. Likewise, the term base station used herein may be referred to as e.g. eNB, eNodeB, NodeB, Base Transceiver Station BTS or Access Point (AP), depending on the technology and terminology used.

[0053] The following description of various embodiments aims at illustrating the principle and concept of the present disclosure. For illustrative purposes, several embodiments of the present disclosure will be described in the context of reference signal (e.g., CSI-RS) configuration and detection in a 3GPP LTE system. Those skilled in the art will appreciate, however, that several embodiments of the present disclosure may be more generally applicable to any other signal configuration and detection, in any other wireless systems.

[0054] In Fig. 1D, an exemplary wireless system 100, in which embodiments of the present invention may be implemented, is illustrated. The wireless system 100 comprises one or more network nodes, e.g., 101, here in the form of an evolved Node B, also known as eNode Bs or eNBs. It will be appreciated that the network node 101 could also be in the form of Node Bs, BTSs (Base Transceiver Stations), BS (Base Station) and/or BSSs (Base Station Subsystems), etc. The network node 101 may provide a macro cell or small cell and provide radio connectivity to a plurality of devices, e.g., UEs 102 -104. The UE can be any wireless communication device which is portable or fixed. Moreover, the UEs 102-104 may, but not necessarily, be associated with a particular end user. Though for illustrative purpose, the wireless system 100 is described to be a 3GPP LTE network, the embodiments of the present disclosure are not limited to such network scenarios and the proposed methods and devices can also be applied to other wireless networks, e.g., a non-cellular network, where the principles described hereinafter are applicable.

[0055] In an embodiment, the network node, e.g., eNB 101 may transmit CSI-RS from multiple antenna ports to facilitate channel estimation and/or CSI measurement at the UE (e.g., UE 102) side. The CSI-RS may be beamformed or non-precoded, as shown in Figs. 1A-1C. In current LTE system, e.g., LTE Release 10, up to 8 antenna ports for CSI-RS transmission are supported. The existing CSI-RS transmission can be configured using parameters shown in Table 1, and details of the parameters can be found in section 6.3.2 of the 3GPP TS 36.331, V10.7.0 "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC) protocol specification."

Table 1. Existing CSI-RS configuration

antennaPortsCount-r10	ENUMERATED {an1, an2, an4, an8},
resourceConfig-r10	INTEGER (0..31),
subframeConfig-r10	INTEGER (0..154),

[0056] For a CSI-RS with more than 8 antenna ports, e.g., up to 16 antenna ports, how to efficiently configure the number of antenna ports or resources is a problem to be solved; however, no corresponding solution is available yet.

[0057] Further, it is observed by the inventor of the disclosure that not only number of antennas, but also antenna arrangement may have impact on the CSI, and corresponding codebook design. For instance, an antenna array with 4 vertical antennas (or, 4 rows) and 2 horizontal antennas (or, 2 columns) can provide maximum 8 antenna ports, and another antenna array with 1 vertical antenna and 8 horizontal antennas can provide same maximum number of antenna ports; however, the resulting CSI characteristic from the two antenna array may be different and require different codebooks for precoding. Current 3GPP specification fails to provide a scheme adaptive to different antenna arrangements.

[0058] In addition, existing CSI-RS configuration signaling shown in Table 1 assumes non-precoded CSI-RS, which may cause a large amount of resource consumption in case of increased number of antenna ports, and thus non-precoded CSI-RS may be used only for scenarios with small number of antenna ports. Beamformed CSI-RS schemes may be more suitable for scenarios with a large number of transceicer units (TxRUs), since existing CSI-RS ports can be used by antenna virtualization of these TxRUs. If both the non-precoded CSI-RS-based scheme and the beamformed CSI-RS-based scheme are to be supported, a base station may need to inform UEs which scheme is used, especially when multiple beams are configured to UE in one CSI-RS process, since CSI computation processes may be different depending on the CSI-RS schemes. For example, in this case of 3D-beamformed CSI-RS, legacy W2 can be reused to feedback beam selection information and inter-polarization co-phase information, i.e. UE only computes and feeds back CSI based on legacy codebook 2 of 8 transmitters after channel estimation of HW_{CSI-RS}. Therefore, when eNB informs UE that this beamformed CSI-RS scheme is adopted by, for example, a RRC signaling, UE should compute and feedback a precoding matrix only based on the legacy codebook 2. The single-user (SU) precoder for data transmission can be formed by:

$$W=W_{CSI-RS}.W2$$

Note that, the CSI computation and feedback procedure of vertically beamformed CSI-RS-based scheme may be same as that of non-precoded CSI-RS, this CSI-RS scheme may needn't to be distinguished with a non-precdoed CSI-RS scheme. In other words, eNB only needs to use a reservation indication in a predefined set to indicate some other schemes, of which CSI computation or/and feedback is different with non-precoded CSI-RS based scheme. Current 3GPP LTE system fails to provide a solution to enable adaptive CSI computation and feedback depending on different CSI-RS configuration schemes.

[0059] It has been observed that one way to provide a CSI-RS with more than 8 antenna ports is to combine multiple existing CSI-RSs with 8 antenna ports or less. In Table 2, existing CSI-RS configurations for 1 or 2, 4, and 8 antenna ports are presented. As shown in Table 2, assuming normal cyclic prefix (CP), For FDD, there are 20 candidate resource configurations for a CSI-RS with 1 or 2 ports, 10 candidate resource configurations for a CSI-RS with 4 antenna ports and 5 candidate resource configurations for a CSI-RS with 8 antenna ports.

Table 2. CSI-RS configurations (Normal CP)

	CSI reference signal configuration	Number of CSI reference signals configured					
		1 or 2		4		8	
		(k',l')	n_s mod 2	(k',l')	n_s mod 2	(k',l')	n_s mod 2
Frame structure type 1 and 2	0	(9,5)	0	(9,5)	0	(9,5)	0
	1	(11,2)	1	(11,2)	1	(11,2)	1
	2	(9,2)	1	(9,2)	1	(9,2)	1
	3	(7,2)	1	(7,2)	1	(7,2)	1
	4	(9,5)	1	(9,5)	1	(9,5)	1
	5	(8,5)	0	(8,5)	0		
	6	(10,2)	1	(10,2)	1		
	7	(8,2)	1	(8,2)	1		
	8	(6,2)	1	(6,2)	1		
	9	(8,5)	1	(8,5)	1		
	10	(3,5)	0				
	11	(2,5)	0				
	12	(5,2)	1				
	13	(4,2)	1				
	14	(3,2)	1				
	15	(2,2)	1				
	16	(1,2)	1				
	17	(0,2)	1				
	18	(3,5)	1				
	19	(2,5)	1				
Frame structure type 2 only	20	(11,1)	1	(11,1)	1	(11,1)	1
	21	(9,1)	1	(9,1)	1	(9,1)	1
	22	(7,1)	1	(7,1)	1	(7,1)	1
	23	(10,1)	1	(10,1)	1		
	24	(8,1)	1	(8,1)	1		
	25	(6,1)	1	(6,1)	1		
	26	(5,1)	1				
	27	(4,1)	1				
	28	(3,1)	1				
	29	(2,1)	1				
	30	(1,1)	1				
	31	(0,1)	1				

[0060] Assuming that a CSI-RS with 16 antenna ports can be provided by combing two 8-port-CSI-RS resource configurations chosen from total 5 configurations for FDD case. The number of candidate configurations available for LTE FDD is $C_5^2 = 10$. It will require 4 bits to indicate one configuration from the 10 candidates, and it means existing 5 bits for resourceConfig-r10 as shown in Table 1 is more than enough for the configuration indication. However, for 12 CSI-RS ports, assuming it can be obtained by combining one 8-port-CSI-RS resource configuration and one 4-port-CSI-RS resource configuration, or by combining three 4-port-CSI-RS resources configurations, the number of candidate configurations available for LTE FDD is more than 32, and the number is even larger for LTE TDD. It means, a candidate configuration cannot be indicated by reusing existing 5 bits for resourceConfig-r10 as shown in Table 1. However, using more bits for the configuration candidate indication means increased signaling overhead, and such overhead increase is unnecessary for 16-port CSI-RS configuration.

[0061] To solve at least part of the problems mentioned above, methods and apparatus for CSI-RS configuration and detection have been proposed herein.

[0062] Fig. 2A illustrates an exemplary flowchart of a method 200 for a reference signal configuration according to an embodiment of the present disclosure. It can be appreciated that the reference signal can be, but not limited to, a CSI-RS. Actually, the method 200 may be applied for configuring any suitable signals and for solving similar problems. The method 200 can be performed by a base station, e.g., the eNB 101 shown in Fig. 1D, but the present disclosure is not limited thereto. In an embodiment, at least part of the method 200 may be performed by another suitable device.

[0063] As shown in Fig. 2A, at block S201, the base station transmit a first indicator to a device for indicating a number of antenna ports for the reference signal (RS), wherein the device can be UE, e.g., the UE 102 shown in Fig. 1D, and the reference signal can be a CSI-RS; at block S202, the base station transmit a second indicator to the device for indicating a resource configuration for a corresponding number of antenna ports for the reference signal; wherein the corresponding number of antenna ports is related to the number indicated by the first indicator, which means the corresponding number can be indicated at least partly by the first indicator; wherein the first indicator may further indicate at least one of: a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal, whether the reference signal is beamformed or not; and part of information on a resource configuration for a predefined number of antenna ports for the reference signal; and/or, wherein the second indicator may further indicate a resource hopping pattern for the indicated number of antenna ports for the reference signal.

[0064] The method 200 provides flexibility for the base station to adopt different RS configurations depending on need and inform UE accordingly to ensure proper RS detection at the UE side.

[0065] In one embodiment, the first indicator may indicate a number of horizontal antenna ports (e.g., using 2 bits) and a number of vertical antenna ports (e.g., using another 2 bits) for the reference signal, separately, and the total number of antenna ports can be derived implicitly. An example is shown in Fig. 2B, where 2 bits are used for indicate the horizontal domain and another 2 bits are used for indicating vertical domain of the antenna array arrangement. Though in this example, the 4 bits are signaled as a field antennaPortsCount-r13 of a CSI-RS configuration signalling, embodiments of the disclosure are not limited thereto.

[0066] In still another embodiment, the first indicator may be an index. For example, assuming there is a predefined set of {1, 2, 4, 8, 12, 16} antenna ports, the first indicator may be an index with a value 5, which points to the 6^{th} element of the predefined set (i.e.,16 antenna ports), that is, the first indicator can indicate the number of antenna ports (16 in this example) for the CSI-RS by indicating an element in the predefined set. In one exemplary element, at least two elements in the predefined set may indicate a same number of antenna ports and different numbers of horizontal antenna ports. For example, the predefined set may be {1 port, 2 ports, 4 ports, 8 ports with 1 or 4 row(s), 8 ports with 2 rows, 12 ports, 16 ports, reserved}, wherein the 4^{th} and the 5^{th} element indicate same number of antenna ports, but different antenna array arrangement, i.e., the 4^{th} element indicates an antenna array with 1 or 4 vertical antennas (8 or 2 horizontal antennas), while the 5^{th} element indicates an antenna array with only 2 vertical antennas (and 4 horizontal antennas). This is designed due to the consideration that the two antenna arrangements (1 or 4 rows, and totally 8 antennas) indicated by the 4^{th} element may result in similar channel characteristic, and thus can be transparent for UE. As for the antenna arrangement of 2 rows and totally 8 antennas, it may result in a different channel characteristic, and thus can be indicated as a different arrangement. Some other antenna configurations with the same total number may also be transparent for UE, e.g. (4 rows, 2 columns) and (1 row, 8 columns); (2 rows, 2 columns) and (1 row, 4 columns); (4 rows, 4 columns) and (2 rows, 8 columns).

[0067] In another example, the predefined set may be {1 port, 2 ports, 4 ports, 8 ports with 1 or 4 rows, 8 ports with 2 rows , 12 ports, 16 ports with 4 rows, 16 ports with 2 rows, reserved …} which also allows multiple antenna arrangement for 16 antenna ports, and may require 4 bits to selecting one element from it.

[0068] A different arrangement may require new codebook design, and if the new codebook cannot introduce large performance gain compared with legacy codebook (e.g., R10 codebook), it may be unnecessary to distinguish this antenna arrangement from other arrangements. For example, if new codebook design for the (2 rows, 4 columns) antenna arrangement cannot provide obvious performance gain, it may be unnecessary to distinguish it with other two 8-port antenna configurations. It may result in only one element in the predefined set for indicating 8 antenna ports. For example, the predefined set may be {1 port, 2 ports, 4 ports, 8 ports, 12 ports, 16 ports with 4 rows, 16 ports with 2 rows, reserved} which may require 3 bits to selecting one element from it.

[0069] In one embodiment, the first indicator may indicate the number of antenna ports for the reference signal by indicating an element in a predefined set, and wherein at least one elements in the predefined set may indicate that the reference signal is beamformed. For instance, the predefined set may be {1, 2, 4, 8, 12,16, beamformed CSI-RS-based scheme, Reserved}, wherein 1, 2, 4, 8, 12 and16 stand for non-precoded CSI-RS with 1, 2, 4, 8, 12, 16 antenna ports respectively, and the 7^{th} element of the predefined set indicate that the CSI-RS is beamformed. In one embodiment, the 7^{th} element may implicitly indicate a predefined number of beams and a predefined number of antenna ports for the beamformed reference signal. For example, it may implicitly indicate a default 3D beamformed CSI-RS with 4 beams and 8 ports. In another embodiment, the 7^{th} element which indicates beamformed CSI-RS may further indicate implicitly no need for reporting some precoding information. For example, it may indicate implicitly that a W1 report based on measurement of the CSI-RS is not necessary, and instead, only W2 is required to be fed back. In another embodiment, the 8^{th} element in the example, i.e., a reserved value, may be used to represent another CSI-RS scheme, e.g., a default vertically beamformed CSI-RS with 2 beams and 16 ports.

[0070] In another embodiment, the predefined set can be {1, 2, 4, 8 ports with 4 rows, 8 ports with 1 row, 12, 16, beamformed CSI-RS-based scheme}. It allows the base station to inform different antenna arrangements and whether beamforming for the CSI-RS is used to the UE.

[0071] In one embodiment, transmitting the first indicator at block S201 may include transmitting the first indicator via a radio resource control (RRC) signaling, e.g., the first indicator may be indicated using a field, e.g., antennaPortsCount-r13 in a CSI-RS configuration signaling. However, embodiments of the disclosure are not limited thereto, actually, the first indicator may be transmitted via any suitable signaling.

[0072] As discussed above, a CSI-RS with 16 ports and a CSI-RS with 12 ports may require different number of bits for the resource configuration indication. For example, in case of 16 CSI-RS ports, the number of candidate configurations denoted as L_{16} can be less than 32 (e.g., L_{16}=10) which requires only 4 bits for indication, while for 12 CSI-RS ports, the number of candidate configurations denoted as L_{12} may be larger than 32 which requires more than 5 bits. To reduce the required signaling overhead, it has been proposed in the disclosure to jointly indicate CSI-RS resource configurations for different number of antenna ports.

[0073] In one embodiment, the first indicator may indicate the number of antenna ports for the reference signal by jointly indicating the number of antenna ports for the reference signal together with the second indicator. For example, the first indicator may indicate 16 antenna ports, and the second indicator may indicate the 11^{th} resource configuration candidate, which exceeds the maximum number of candidates for 16 antenna ports. In such a case, the first indicator and the second indicator may jointly indicate a CSI-RS with 12 antenna ports. Correspondingly, the resource configuration indicated by the second indicator is interpreted as a configuration for 12 antenna ports. The second indicator indicates a resource configuration for a corresponding number of antenna ports for the reference signal at block S202, and the corresponding number of antenna ports can be different from that indicated by the first indicator at block S201.

[0074] One example for a joint indication by the first indicator and the second indicator is shown in Table 3. In this example, the first indicator is a field denotes as antennaPortsCount-r13, and the second indicator is a field denoted as resourceConfig-r13, in a RRC signaling CSI-RS-Config-r13. In case the second indicator indicates a configuration candidate in a region for 12 ports, the first indicator, which indicates 16 antenna ports explicitly, should be interpreted as indicating 12 antenna ports. By this way, some resource configuration overhead for 16 antenna ports can be used for 12 ports resource configuration, and thereby increasing number of configuration candidates available for 12 antenna ports. For example, assuming L_{16}=10, then number of resource configuration candidate available for 12 antenna ports can be (32-10)+32=54.

Table 3. Example for joint indication of number of antenna ports

CSI-RS-Config-r13	
antennaPortsCount-r13	16
resourceConfig-r13	INTEGER ($\underbrace{0 \ldots L_{16}-1,}_{\text{For 16 ports}}$ $\underbrace{L_{16} \ldots 31}_{\text{For 12 ports}}$),
subframeConfig-r13	

[0075] The joint indication is also useful in another scenario for power boosting, where a CSI-RS with a large number of antenna ports are obtained by combining multiple (e.g., 2) CSI-RSs with a small number of antenna ports (e.g., 8 or less), for example, multiple existing CSI-RS with 1, 2, 4, or 8 antenna ports with the configurations shown in Table 2. Take 12 antenna ports for example, it can be obtained by combining 8 antenna ports in symbols 5 and 6 of slot 0 and 4 antenna ports in symbols 2 and 3 of slot 1, as shown in Fig. 3A. In the example shown in Fig. 3A, in symbol 5 or 6 of slot 0, 4 CSI-RS antenna ports (port 15/16, 19/20, 17/18, 21/22) are frequency divisionally multiplexed (FDMed), which means, natural power boosting for one antenna port up to 4 times (6dB) can be achieved by using power of 3 NULL resource elements (REs); while in symbol 2 or 3 of slot 1, only two antenna ports (ports 23/24 and 25/26) are FDMed, which means power for one antenna port can be boosted by 2 times (i.e., 3dB) by using power of 1 NULL RE. The difference in power boosting capability in slot 0 and 1 is not desired, since it causes EPRE of different CSI-RS ports to be different, and the difference cannot be informed to the receivers based on existing signaling of current LTE specification. Though it is possible to keep CSI-RS EPRE in slot 0 and slot 1 constant by putting restriction on the power of the CSI-RS in slot 0, it leads to waste of power and limited CSI-RS coverage.

[0076] The problem in the above scenario can be solved using one embodiment of the method 200 shown in Fig. 2A. For example, the first indicator can indicate part of information on a resource configuration for a predefined number of antenna ports for the RS (e.g., CSI-RS) by jointly indicating the resource configuration for a corresponding number of antenna ports for the reference signal together with the second indicator, and wherein when the first indicator indicates a first predefined number of antenna ports (e.g., 12), the second indicator may indicate a resource configuration for a second predefined number (e.g., 16) of antenna ports which is different from the first predefined number of antenna ports. With this embodiment, the base station is allowed to configure 12 antenna ports by transmitting the first indicator (e.g., antennaPortsCount-r13 = 12) at block S201, but configure a 16-port CSI-RS resource by transmitting the second indicator (e.g., resourceConfig-r13) at block S202, such that, the resource for 16 antenna ports can be configured as shown in Fig. 3B, though only 12 ports are used for real CSI-RS transmission. By this way, a CSI-RS resource including two 8-port resources is configured, and in both slot 0 and slot 1, there are 4 antenna ports FDMed, which means power boosting by 4 times is possible, as shown in Figs. 3C and 3D. That is, with this embodiment, equal power boosting capability can be achieved for slot 0 and slot 1, without causing power waste or CSI-RS coverage reduction.

[0077] As discussed above, for a 12-port or 16-port CSI-RS obtained by combining multiple 8-port or 4-port CSI-RSs, there can be multiple configuration candidates. For example, for a 16-port CSI-RS, the number of candidate configurations can be L_{16}=10, and for a 12-port CSI-RS, the number of candidate configurations may be L_{12}=54. More candidates require more signaling overhead for a configuration indication. Moreover, is has been observed by the inventor of the disclosure that some combinations to get the 12-port or 16-port are not promising and should be avoided. For example, it may not be desirable to combine two existing CSI-RS resource configurations (e.g., configurations 0 and 4 as shown in Fig. 4A) which are far from each other in time domain, since it may lead to a phase shift for the two groups of antenna ports and correspondingly lead to an inaccurate CSI measurement. Therefore, it has been proposed herein to reduce the number of resource configuration candidates in order to reduce signaling overhead, by avoiding unnecessary configurations. This can be implemented using one embodiment of the method 200.

[0078] In this embodiment, the second indicator can indicate the resource configuration by indicating a resource configuration for N antenna ports from a predefined configuration set, which includes part but not all configuration candidates formed by combining L resource configurations for K antenna ports, and wherein N=LxK and N, L and K are all positive integers. For example, the second indicator may indicate one configuration for N=16 antenna ports from a predefined configuration set, wherein the predefined set may include some (e.g., less than L_{16}=10) selected configurations which are formed by combining L=2 CSI-RS configurations for K=8 ports. In one embodiment, to obtain a 16-port CSI-RS resource configuration, the existing CSI-RS configurations for 8 ports may be indexed, for example, as shown in Fig. 4A, and then a 16-port CSI-RS configuration can be obtained by combing two 8-port CSI-RS configurations which have contiguous indexes, e.g., a combination of {configuration 0, configuration 1} or {configuration 2, configuration 3} is allowed. That is, the predefined set may only include those configurations which are obtained by combining 8-port CSI-RS configurations with contiguous indexes.

[0079] It can be appreciated that a predefined set for 12-port CSI-RS configurations can be defined in similar way. For example, the existing CSI-RS configurations for 4 ports may be indexed, for example, as shown in Fig. 4B, and the indexes can be further arranged in an order of {0, 5, 1, 6, 2, 7, 3, 8, 4, 9}and then a 12-port CSI-RS configuration can be obtained by combing three 4-port CSI-RS configurations which are contiguous according to the order, e.g., a combination of {configuration 0, configuration 5, configuration 1} or {configuration 6, configuration 2, configuration 7}or {configuration 3, configuration 8, configuration 4} can be allowed. In this example, the predefined set for 12-port CSI-RS only includes 3 configuration candidates.

[0080] It is further observed that in above examples, only very few candidate configurations are supported for 12 and 16 ports, and some CSI-RS resources are always left unused, e.g., for 12-port CSI-RS resource configuration, the resource configuration 9 of an existing 4-port CSI-RS is unused; and for 16-port CSI-RS resource configuration, both the resource configurations 4 and 9 of an existing 4-port CSI-RS are unused. To make full use of the CSI-RS resources and increase possible configurations for new large number of CSI-RS ports, in some embodiment, overlapping between different candidate resource configurations can be allowed. That is, at least two configuration candidates in the predefined configuration set may indicate partly overlapped resources for the N antenna ports. In Fig. 4C, examples for 12-port and 16-port CSI-RS resource configurations with overlapping are presented, wherein each 12-port configuration and 16-port configuration are obtained by combining 3 and 4 contiguous 4-port CSI-RS configurations, respectively. As shown in Fig. 4C, by allowing resource overlapping, up to 10 candidate configurations can be achieved, that is, the predefined set may include 10 elements. In the example, the maximum number of candidate configurations (i.e., number of elements in the predefined set) equals to the number of candidate configurations of the existing 4-port CSI-RS.

[0081] In another embodiment, the second indicator transmitted at block S202 may indicate the resource configuration for the corresponding number of antenna ports by indicating a resource configuration from a predefined configuration set, and at least one configuration candidates in the predefined configuration set indicate a predefined resource hopping pattern for the corresponding number of antenna ports. Such an embodiment allows CSI-RS resource hopping, which can provide better CSI-RS measurement for both beamformed CSI-RS and non-precoded CSI-RS, and realize inter-cell interference randomization.

[0082] In one embodiment, the predefined resource hopping pattern may indicate resource change for at least part of the corresponding number of N antenna ports in different physical resource blocks (PRBs) or different subframes. With this embodiment, the base station can indicate, to the device, CSI-RS resource change in different PRBs and/or subframes, and thus allows more flexible CSI-RS configuration and interference randomization.

[0083] In case beamformed CSI-RS is configured, the resource for the CSI-RS may change on a per-beam basis, and the predefined resource hopping pattern may indicate the resource change in different PRBs or different subframes on a per-beam basis. Examples for the per-beam resource hopping are shown in Figs. 5A-5B. a 3D beamforming can be as shown in Fig. 1A, wherein each beam is obtained by antenna virtualization and transmitted from 2 antenna ports. Fig. 5A shows the resource hopping for each of 6 CSI-RS beams (denoted as beam 0, beam 1, beam 2, beam 3, beam 4 and beam 5 in Fig. 5A) in subframe i and subframe j. A vertical beamforming can be as shown in Fig. 1B, wherein each beam is transmitted from 8 antenna ports. Fig. 5B shows the resource hopping for each of 2 CSI-RS beams (denoted as beam 0 and beam 1 in Fig. 5B) in subframe i and subframe j. It can be appreciated that the frequency hopping can also be done in frequency domain, i.e., resource for a beam can be different in different PRBs, in another embodiment. In some embodiments, the resource for a beam may change with both PRB and subframe.

[0084] In one embodiment, the second resource indicator may be an index, which indicating for example an element in a predefined set. The predefined set may include P configurations, e.g., {1, 2, 3, 4,...P}, wherein some of the configuration (e.g., configurations 1 to 4) may indicate non-hopping resource configurations, while other configurations (e.g., 5 to P) may indicate resource configurations with hopping. For example, if the second indicator takes a value of 5, it may be interpreted as a resource configuration with a predefined hopping pattern, for example, as shown in Fig. 5A.

[0085] One exemplary procedure for implementing CSI-RS hopping is illustrated schematically in Fig. 6A. In this example, a 2D antenna array is split into multiple groups and/or multiple sets based on different characteristics of antenna ports, and then the antenna ports are mapped to CSI-RS resources. The resources can be as that shown in Figs. 3A, 3B and Figs. 4A and 4B. The resource for a CSI-RS with more than 8 ports can be a combination of multiple existing CSI-RS configurations as shown in Table 2. The CSI-RS hopping can be realized by changing the resource mapping in different frequencies (e.g., PRBs), time instances (e.g., subframes) or, codes. There can be intra-group, inter-group hopping, intra-set or inter-set hopping patterns. The hopping pattern can be default information known to both NB and UEs, e.g., the hopping pattern can be determined implicitly based on cell ID. Alternatively, the base station (e.g., eNB) can inform the hopping pattern to UE via a RRC signaling, e.g., via the second indicator transmitted at block S202.

[0086] Figs. 6B-6C provide examples for resource hopping of non-precoded CSI-RS. Though 16-port CSI-RSs are illustrated, it can be appreciated that similar hopping can be applied to CSI-RS with other number of antenna ports. Based on different characteristic, the 2D antenna array can be split into different antenna groups. As shown in Fig. 6B, the 16 antenna ports can be divided into 2 groups ({0, 4, 1, 5, 2, 6, 3, 7} and {8, 12, 9, 13, 10, 14, 11, 15}) based on antenna position, e.g., based on the index of the row of antennas. The number of groups equals to the number of rows of antenna ports, and these groups from a set 0. In different subframes, the resource for each group of antenna ports may change. It can be appreciated, in another embodiment, the resource for each group may change in different PRBs. It is shown in Fig. 6C, in another embodiment, based on antenna positions, the antenna ports may be divided into a group 0 and a group 1 which form a set 0, and based on different polarization, the antenna ports may also be divided into a group 2 and a group 3 which form a set 1, and the number of groups equals to the number of polarizations in this case. In such case, a resource hopping pattern may be defined to allow inter-set resource hopping. For example, as shown in Fig. 6C, resource for antenna ports of group 0, set 0 in subframe i may be used for antenna ports of group 2, set 1 in subframes later (i.e., subframe i+n). Likewise, resource for antenna ports of group 1, set 0 in subframe i may be used for antenna ports of group 3, set 1 in subframes later (i.e., subframe i+n).

[0087] It can be appreciated, that the resource hopping may include resource change in time, and/or frequency, and/or code domain. In Fig. 6D, an example for CSI-RS hopping in different PRBs is illustrated. In this example, assuming 2 antenna ports groups ({0, 4, 1, 5, 2, 6, 3, 7} and {8, 12, 9, 13, 10, 14, 11, 15}) are obtained based on antenna position, as shown in Fig. 6B. It can be observed from Fig. 6D, resource for antenna ports of group 0 in PRB i may be used for antenna ports of group 1 in PRB j.

[0088] In another embodiment, the method 200 may further comprise transmitting a third indicator to the device for indicating whether resource hopping for the reference signal is enabled or not, at block S203. For example, if the third indicator indicates that resource hopping is enabled, the receiver may use the second indicator to select one resource configuration with hopping from a predefined resource configuration set, and if the third indicator indicates that resource hopping is not enabled, the receiver may use the second indicator to select one resource configuration without hopping from another predefined resource configuration set.

[0089] Fig. 7 illustrates an exemplary flowchart of a method 700 for a reference signal detection according to an embodiment of the present disclosure. It can be appreciated that the reference signal can be, but not limited to, CSI-RS. Actually, the method 700 may apply to detection of any suitable signals to solve similar problems. The method 700 can be performed by a device, e.g., the UE 102 shown in Fig. 1D, but the present disclosure is not limited thereto. The method 700 may also be performed by any other suitable device.

[0090] As shown in Fig. 7, the method 700 comprises receiving, from a base station, a first indicator for indicating a number of antenna ports for the reference signal at block S701; receiving, from the base station, a second indicator for indicating a resource configuration for a corresponding number of antenna ports for the reference signal at block S702; and detecting the reference signal based on the received first indicator and the received second indicator at block S703; wherein the first indicator further indicates at least one of: a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal, whether the reference signal is beamformed or not, and part of information on a resource configuration for a predefined number of antenna ports for the reference signal; and/or, wherein the second indicator further indicates a resource hopping pattern for the indicated number of antenna ports for the reference signal. The received first indicator and second indicator enable the device to detect the reference signals from the base station properly.

[0091] Regarding the detection in accordance with the received first indicator and second indicator at block S703, it can be performed in a conventional way. In one embodiment, it may comprise adjusting a CSI-RS feedback procedure based on whether the CSI-RS is beamformed for not.

[0092] In another embodiment, the device may interpret the first indicator and the second indicator separately, to get the configured number of antenna ports for the reference signal, and the corresponding resource configuration. In still another embodiment, the device may interpret the first indicator and the second indicator jointly, to get the configured number of antenna ports for the reference signal, and the corresponding resource configuration.

[0093] In some embodiments, the first indicator and the second indicator may be those transmitted by the base station at block S201 and block S202, and related descriptions provided with reference to Fig. 2A and method 200 will also apply here, and thus details of the first indicator and the second indicator will not be repeated here.

[0094] In another embodiment of the disclosure, the method 700 may further comprise receiving, from the base station, a third indicator for indicating whether resource hopping for the reference signal is enabled or not at block S704, and wherein detecting the reference signal based on the received first indicator and the received second indicator may comprise detecting the reference signal also based on the received third indicator.

[0095] In one aspect of the disclosure, there is also provided a method 800, which may comprise at least one of blocks S201, S202 and S203 of the method 200, as shown in Figs. 8A-8E. That is, the method 800 may comprise block S201 only, block S202 only, block S203 only, block S201 and block S203 or, block S202 and S203.

[0096] In one embodiment, the method 800 may only comprise the block S201, for configuring number of antenna ports for a reference signal. That is, with the method 800, a base station may transmit a first indicator to a device for indicating a number of antenna ports for the reference signal; and wherein the first indicator may further indicate at least one of: a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal, whether the reference signal is beamformed or not; and part of information on a resource configuration for a predefined number of antenna ports for the reference signal.

[0097] In one embodiment, in the method 800, the first indicator may indicate the number of antenna ports for the reference signal by indicating an element in a predefined set, and wherein at least two elements in the predefined set may indicate a same number of antenna ports and different numbers of horizontal antenna ports. In another embodiment, the first indicator may indicate the number of antenna ports for the reference signal by indicating an element in a predefined set, and wherein at least one element in the predefined set may indicate that the reference signal is beamformed. In a further embodiment, the at least one elements in the predefined set may further indicate implicitly a predefined number of beams and a predefined number of antenna ports for the reference signal.

[0098] Alternatively, the method 800 may only comprise the block S202, for configuring resource for a reference signal. That is, with the method 800, a base station may transmit a second indicator to the device for indicating a resource configuration for a corresponding number of antenna ports for the reference signal; and in some embodiments the second indicator may further indicate a resource hopping pattern for the corresponding number of antenna ports for the reference signal.

[0099] In one embodiment, the second indicator may indicate the resource configuration by indicating a resource configuration for N antenna ports from a predefined configuration set, which includes part but not all configuration candidates formed by combining L resource configurations for K antenna ports, and wherein N=LxK and N, L and K are all positive integers. In another embodiment, at least two configuration candidates in the predefined configuration set may indicate partly overlapped resources for the N antenna ports.

[00100] In another embodiment, the second indicator may indicate the resource configuration by indicating a resource configuration for the corresponding number of antenna ports from a predefined configuration set, and at least one configuration candidates in the predefined configuration set may indicate a predefined resource hopping pattern for the corresponding number of antenna ports. In still another embodiment, the predefined resource hopping pattern may indicate resource change for at least part of the corresponding number of antenna ports in different physical resource blocks or different subframes. In one embodiment, the predefined resource hopping pattern may indicate the resource change for the at least part of the corresponding number of antenna ports in different physical resource blocks or different subframes on a per-beam basis.

[00101] Alternatively, or additionally, the method 800 may comprise block S203, i.e., the base station transmits a third indicator to a device for indicating whether resource hopping for a reference signal is enabled or not.

[00102] As described, the method 800 may comprise block S201 and block S203, or bock S202 and block S203 in another embodiment. Since these blocks have been described above and with reference to Fig. 2A and method 200, related details will not be repeated here.

[00103] Likewise, in another aspect of the disclosure, there is also provided a method which may comprise at least one of the blocks S701, S702, S703 and S704 of the method 700.

[00104] For example, the method may only comprise block S701 and S703, that is, a device may receive, from a base station, a first indicator for indicating a number of antenna ports for the reference signal at block S701, wherein the first indicator may further indicate at least one of: a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal, whether the reference signal is beamformed or not, and part of information on a resource configuration for a predefined number of antenna ports for the reference signal; and the device detect the reference signal based on the received first indicator at block S703.

[00105] In another embodiment, the method may only comprise block S702 and S703, that is, the device may receive, from a base station, a second indicator for indicating resource allocation for a corresponding number of antenna ports for the reference signal at block S702, wherein the second indicator may further indicate a resource hopping pattern for the indicated number of antenna ports for the reference signal; and the device detect the reference signal based on the received second indicator at block S703.

[00106] In another embodiment of the disclosure, additionally, or alternatively, the method may comprise block S704, i.e., the device may receive, from the base station, a third indicator for indicating whether resource hopping for the reference signal is enabled, and at block S703, the device may detect the reference signal based on the received third indicator.

[00107] Reference is now made to Fig. 9, which illustrates a schematic block diagram of an apparatus 900 in a wireless system for configuring a reference signal according to an embodiment of the present disclosure. In one embodiment, the apparatus 900 may be implemented as a base station, or a part thereof. Alternatively or additionally, the apparatus 900 may be implemented as any other suitable network element in the wireless communication system. The apparatus 900 is operable to carry out the example method 200 described with reference to Fig. 2A, or method 800, and possibly any other processes or methods. It is also to be understood that the method 200 or 800 is not necessarily carried out by the apparatus 900. At least some blocks of the method 200 or 800 can be performed by one or more other entities.

[00108] As illustrated in Fig. 9, the apparatus 900 may comprise a first transmitting unit 901, configured to transmit a first indicator to a device for indicating a number of antenna ports for the reference signal; wherein the first indicator may further indicate at least one of: a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal, whether the reference signal is beamformed or not; and part of information on a resource configuration for a predefined number of antenna ports for the reference signal.

[00109] Additionally, or alternatively, the apparatus 900 may comprise a second transmitting unit 902, configured to transmit a second indicator to the device for indicating a resource configuration for a corresponding number of antenna ports for the reference signal, wherein the corresponding number may be related to the number indicated by the first indicator; and wherein the second indicator may further indicate a resource hopping pattern for the indicated number of antenna ports for the reference signal.

[00110] In one embodiment, alternatively or additionally, the apparatus 900 may comprise a third transmitting unit 903, configured to transmit a third indicator to the device for indicating whether resource hopping for the reference signal is enabled.

[00111] The characteristics of the first indicator and the second indicator described above with reference to method 200 and 800 also apply here, and thus related details will not be repeated here.

[00112] In Fig. 10, a schematic block diagram of an apparatus 1000 in a wireless system for detecting a reference signal according to an embodiment of the present disclosure is illustrated. In one embodiment, the apparatus 1000 may be implemented as a device, e.g., UE 102 shown in

Fig. 1D, or a part thereof. Alternatively or additionally, the apparatus 1000 may be implemented as any other suitable devices in the wireless communication system. The apparatus 1000 is operable to carry out at least part of the example method 700 described with reference to Fig. 7, and possibly any other processes or methods. It is also to be understood that the method 700 is not necessarily carried out by the apparatus 1000. At least some blocks of the method 700 can be performed by one or more other entities.

[00113] As illustrated in Fig. 10, the apparatus 1000 may comprise a first receiving unit 1001, configured to receive, from a base station, a first indicator for indicating a number of antenna ports for the reference signal; wherein the first indicator further indicates at least one of: a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal, whether the reference signal is beamformed or not; and part of information on a resource configuration for a predefined number of antenna ports for the reference signal.

[00114] Alternatively or additionally, the apparatus 1000 may comprise a second receiving unit 1002, configured to receive from the base station a second indicator for indicating a resource configuration for a corresponding number of antenna ports for the reference signal; wherein the second indicator may further indicate a resource hopping pattern for the indicated number of antenna ports for the reference signal.

[00115] Alternatively or additionally, the apparatus 100 may comprise a third receiving unit 1004, configured to receive, from the base station, a third indicator for indicating whether resource hopping for the reference signal is enabled.

[00116] In another embodiment, the apparatus 1000 may comprise a detection unit 1003, configured to detect the reference signal based on the received first indicator and/or the received second indicator, and/or the received third indicator.

[00117] It can be appreciated that some modules in the apparatus 900 and 1000 can be combined in some implementations. For example, in one embodiment, it is possible to use a single transmitting unit to transmit the first indicator and the second indicator.

[00118] Fig. 11 illustrates a simplified block diagram of an apparatus 1110, and an apparatus 1120 that are suitable for use in practicing the embodiments of the present disclosure. The apparatus 1110 may be a base station; the apparatus 1120 may be a UE.

[00119] The apparatus 1110 comprises at least one processor 1111, such as a data processor (DP) and at least one memory (MEM) 1112 coupled to the processor 1111. The apparatus may further comprise a suitable RF transmitter TX and receiver RX 1113 (which may be implemented in a single component or separate components) coupled to the processor 1111. The MEM 1112 stores a program (PROG) 1114. The PROG 1114 may include instructions

that, when executed on the associated processor 1111, enable the apparatus 1110 to operate in accordance with the embodiments of the present disclosure, for example to perform the method 200 or 800. The TX/RX 1113 may be used for bidirectional radio communication with other apparatuses or devices in the network, e.g. the apparatus 1120. Note that the TX/RX 1113 may have multiple antennas (e.g., an AAS) to facilitate the communication. A combination of the at least one processor 1111 and the at least one MEM 1112 may form processing means 1115 adapted to implement various embodiments of the present disclosure.

[00120] The apparatus 1120 comprises at least one processor 1121, such as a DP, at least one MEM 1122 coupled to the processor 1121. The apparatus 1120 may further comprise a suitable RF TX/ RX 1123 (which may be implemented in a single component or separate components) coupled to the processor 1121. The MEM 1122 stores a PROG 1124. The PROG 1124 may include instructions that, when executed on the associated processor 921, enable the apparatus 1120 to operate in accordance with the embodiments of the present disclosure, for example to perform the method 700 or part of it. The TX/RX 1123 is for bidirectional radio communications with other apparatuses or devices in the network, e.g. the apparatus 1110. Note that the TX/RX 1123 may have multiple antennas to facilitate the communication. A combination of the at least one processor 1121 and the at least one MEM 1122 may form processing means 1125 adapted to implement various embodiments of the present disclosure.

[00121] Various embodiments of the present disclosure may be implemented by computer program executable by one or more of the processor 1111, 1121 in software, firmware, hardware or in a combination thereof.

[00122] The MEMs 1112, 1122 may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory, as non-limiting examples. While only one MEM is shown in the apparatuses 1110, 1120, there may be several physically distinct memory units in them.

[00123] The processors 1111, 1121 may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on multicore processor architecture, as non-limiting examples. Each of the apparatuses 1110, 1120 may have multiple processors, such as an application specific integrated circuit (ASIC) chip that is slaved in time to a clock which synchronizes the main processor.

[00124] Although the above description is made in the context of LTE, it should not be construed as limiting the spirit and scope of the present disclosure. The idea and concept of the present disclosure can be generalized to also cover other wireless networks including non-cellular network, e.g., ad-hoc network.

[00125] In addition, the present disclosure provides a carrier containing the computer program as mentioned above, wherein the carrier is one of an electronic signal, optical signal, radio signal, or computer readable storage medium. The computer readable storage medium can be, for example, an optical compact disk or an electronic memory device like a RAM (random access memory), a ROM (read only memory), Flash memory, magnetic tape, CD-ROM, DVD, Blue-ray disc and the like.

[00126] The techniques described herein may be implemented by various means so that an apparatus implementing one or more functions of a corresponding apparatus described with an embodiment comprises not only prior art means, but also means for implementing the one or more functions of a corresponding apparatus described with an embodiment and it may comprise separate means for each separate function, or means may be configured to perform two or more functions. For example, these techniques may be implemented in hardware (one or more apparatuses), firmware (one or more apparatuses), software (one or more modules), or combinations thereof. For a firmware or software, implementation may be made through modules (e.g., procedures, functions, and so on) that perform the functions described herein.

[00127] Exemplary embodiments herein have been described above with reference to block diagrams and flowchart illustrations of methods, apparatuses, i.e. systems. It will be understood that each block of the block diagrams and flowchart illustrations, and combinations of blocks in the block diagrams and flowchart illustrations, respectively, can be implemented by various means including computer program instructions. These computer program instructions may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions which execute on the computer or other programmable data processing apparatus create means for implementing the functions specified in the flowchart block or blocks.

[00128] While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any implementation or of what may be claimed, but rather as descriptions of features that may be specific to particular embodiments of particular implementations. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single

embodiment can also be implemented in multiple embodiments separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or variation of a sub-combination.

[00129] It should also be noted that the above described embodiments are given for describing rather than limiting the disclosure, and it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the disclosure as those skilled in the art readily understand. Such modifications and variations are considered to be associated with the scope of the disclosure and the appended claims. The protection scope of the disclosure is defined by the accompanying claims.

WHAT IS CLAIMED IS:

1. A method for reference signal configuration in a multiple input multiple output system, comprising:

transmitting a first indicator to a device for indicating a number of antenna ports for the reference signal; and

transmitting a second indicator to the device for indicating a resource configuration for a corresponding number of antenna ports for the reference signal, wherein the corresponding number is related to the number indicated by the first indicator;

wherein

the first indicator further indicates at least one of:

a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal,

whether the reference signal is beamformed or not; and

part of information on a resource configuration for a predefined number of antenna ports for the reference signal,

and/or

the second indicator further indicates a resource hopping pattern for the indicated number of antenna ports for the reference signal.

2. The method according to claim 1, wherein the first indicator indicates the number of antenna ports for the reference signal by indicating an element in a predefined set, and wherein at least two elements in the predefined set indicate a same number of antenna ports and different numbers of horizontal antenna ports.

3. The method according to claim 1, wherein the first indicator indicates the number of antenna ports for the reference signal by indicating an element in a predefined set, and wherein at least one elements in the predefined set indicate that the reference signal is beamformed.

4. The method according to claim 3, wherein the at least one elements in the predefined set further indicate implicitly a predefined number of beams and a predefined number of antenna ports for the reference signal.

5. The method according to claim 1, wherein the first indicator indicates the number of antenna ports for the reference signal by jointly indicating the number of antenna ports for the reference signal together with the second indicator.

6. The method according to claim 1, wherein the first indicator indicates part of information on a resource configuration for a predefined number of antenna ports for the reference signal by jointly indicating the resource configuration for the corresponding number of antenna ports for the reference signal together with the second indicator, and wherein when the first indicator indicates a first predefined number of antenna ports, the second indicator indicates a resource configuration for a second predefined number of antenna ports which is different from the first predefined number of antenna ports.

7. The method according to claim 1, wherein the second indicator indicates the resource configuration by indicating a resource configuration for N antenna ports from a predefined configuration set, which includes part but not all configuration candidates formed by combining L resource configurations for K antenna ports, and wherein N=LxK and N, L and K are all positive integers.

8. The method according to claim 7, wherein at least two configuration candidates in the predefined configuration set indicate partly overlapped resources for the N antenna ports.

9. The method according to claim 1, wherein the second indicator indicates the resource configuration by indicating a resource configuration for the corresponding number of antenna ports from a predefined configuration set, and at least one configuration candidates in the predefined configuration set indicate a predefined resource hopping pattern for the corresponding number of antenna ports.

10. The method according to claim 9, wherein the predefined resource hopping pattern indicates resource change for at least part of the corresponding number of antenna ports in different physical resource blocks or different subframes.

11. The method according to claim 10, wherein the predefined resource hopping pattern indicates the resource change for the at least part of the corresponding number of antenna ports in different physical resource blocks or different subframes on a per-beam basis.

12. The method according to claim 1, further comprising:

transmitting a third indicator to the device for indicating whether resource hopping for the reference signal is enabled.

13. A method for reference signal detection in a multiple input multiple output system, comprising:

receiving, from a base station, a first indicator for indicating a number of antenna ports for the reference signal; and

receiving from the base station a second indicator for indicating a resource configuration for a corresponding number of antenna ports for the reference signal, wherein the corresponding number is related to the number indicated by the first indicator; and

detecting the reference signal based on the received first indicator and the received second indicator;

wherein

the first indicator further indicates at least one of:

a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal,

whether the reference signal is beamformed or not; and

part of information on a resource configuration for a predefined number of antenna ports for the reference signal,

and/or

the second indicator further indicates a resource hopping pattern for the indicated number of antenna ports for the reference signal.

14. The method according to claim 13, further comprising:

receiving, from the base station, a third indicator for indicating whether resource hopping for the reference signal is enabled, and

wherein detecting the reference signal based on the received first indicator and the received second indicator comprises detecting the reference signal also based on the received third indicator.

15. An apparatus for reference signal configuration in a multiple input multiple output system, comprising:

a first transmitting unit, configured to transmit a first indicator to a device for indicating a number of antenna ports for the reference signal; and

a second transmitting unit, configured to transmit a second indicator to the device for indicating a resource configuration for a corresponding number of antenna ports for the reference signal, wherein the corresponding number is related to the number indicated by the first indicator;

wherein the first indicator further indicates at least one of:

a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal,

whether the reference signal is beamformed or not; and

part of information on a resource configuration for a predefined number of antenna ports for the reference signal,

and/or

wherein the second indicator further indicates a resource hopping pattern for the indicated number of antenna ports for the reference signal.

16. The apparatus according to claim 15, wherein the first indicator indicates the number of antenna ports for the reference signal by indicating an element in a predefined set, and wherein at least two elements in the predefined set indicate a same number of antenna ports and different numbers of horizontal antenna ports.

17. The apparatus according to claim 15, wherein the first indicator indicates the number of antenna ports for the reference signal by indicating an element in a predefined set, and wherein at least one elements in the predefined set indicate that the reference signal is beamformed.

18. The apparatus according to claim 17, wherein the at least one elements in the predefined set further indicate implicitly a predefined number of beams and a predefined number of antenna ports for the reference signal.

19. The apparatus according to claim 15, wherein the first indicator indicates the number of antenna ports for the reference signal by jointly indicating the number of antenna ports for the reference signal together with the second indicator.

20. The apparatus according to claim 15, wherein the first indicator indicates part of information on a resource configuration for a predefined number of antenna ports for the reference signal by jointly indicating the resource configuration for the corresponding number of antenna ports for the reference signal together with the second indicator, and wherein when the first indicator indicates a first predefined number of antenna ports, the second indicator indicates a resource configuration for a second predefined number of antenna ports which is different from the first predefined number of antenna ports.

21. The apparatus according to claim 15, wherein the second indicator indicates the resource configuration by indicating a resource configuration for N antenna ports from a predefined configuration set, which includes part but not all configuration candidates formed by combining L resource configurations for K antenna ports, and wherein N=LxK and N, L and K are all positive integers.

22. The apparatus according to claim 21, wherein at least two configuration candidates in the predefined configuration set indicate partly overlapped resources for the N antenna ports.

23. The apparatus according to claim 15, wherein the second indicator indicates the resource configuration by indicating a resource configuration for the corresponding number of antenna ports from a predefined configuration set, and at least one configuration candidates in the predefined configuration set indicate a predefined resource hopping pattern for the corresponding number of antenna ports.

24. The apparatus according to claim 23, wherein the predefined resource hopping pattern indicates resource change for at least part of the corresponding number of antenna ports in different physical resource blocks or different subframes.

25. The apparatus according to claim 24, wherein the predefined resource hopping pattern indicates the resource change for the at least part of the corresponding number of antenna ports in different physical resource blocks or different subframes on a per-beam basis.

26. The apparatus according to claim 15, further comprising:

A third transmitting unit, configured to transmit a third indicator to the device for indicating whether resource hopping for the reference signal is enabled.

27. An apparatus for reference signal detection in a multiple input multiple output system, comprising:

a first receiving unit, configured to receive, from a base station, a first indicator for indicating a number of antenna ports for the reference signal; and

a second receiving unit, configured to receive from the base station a second indicator for indicating a resource configuration for a corresponding number of antenna ports for the reference signal, wherein the corresponding number is related to the number indicated by the first indicator; and

a detection unit, configured to detect the reference signal based on the received first indicator and the received second indicator;

wherein the first indicator further indicates at least one of:

a number of horizontal antenna ports and a number of vertical antenna ports for the reference signal,

whether the reference signal is beamformed or not; and

part of information on a resource configuration for a predefined number of antenna ports for the reference signal

and/or

wherein the second indicator further indicates a resource hopping pattern for the indicated number of antenna ports for the reference signal.

28. The apparatus according to claim 26, further comprising:

a third receiving unit, configured to receive, from the base station, a third indicator for indicating whether resource hopping for the reference signal is enabled, and

wherein the detection unit is further configured to detect the reference signal also based on the received third indicator.

29. An apparatus for reference signal configuration in a wireless system, comprising a processor and a memory, said memory containing instructions executable by said processor whereby said apparatus is operative to perform the method of any of Claims 1-12.

30. An apparatus for reference signal detection in a wireless system, comprising a processor and a memory, said memory containing instructions executable by said processor whereby said apparatus is operative to perform the method of any of Claims 13-14.

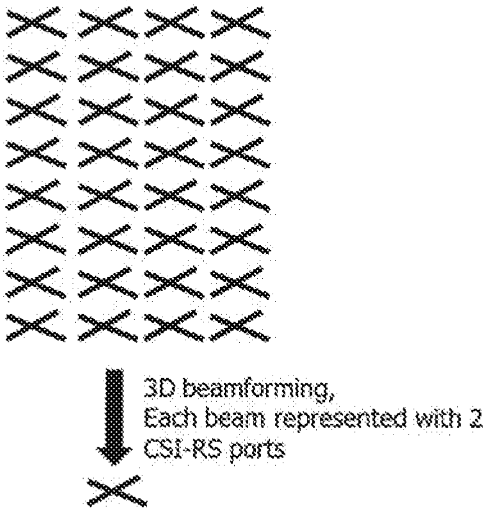

Fig. 1A

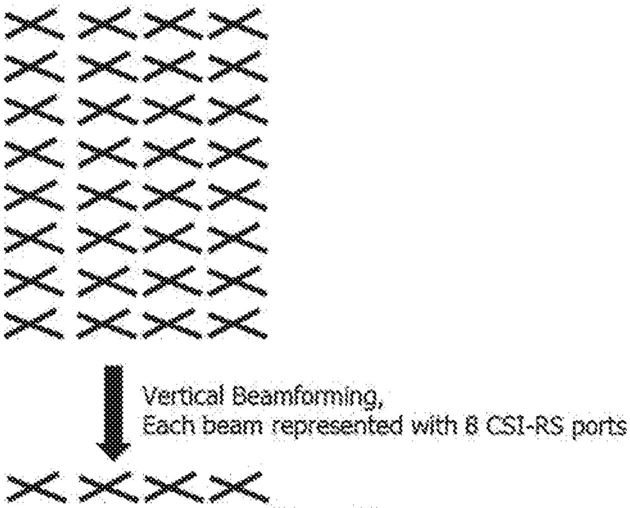

Fig. 1B

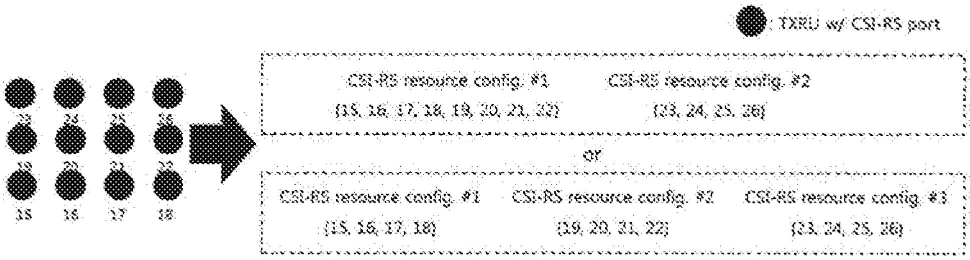

Fig. 1C

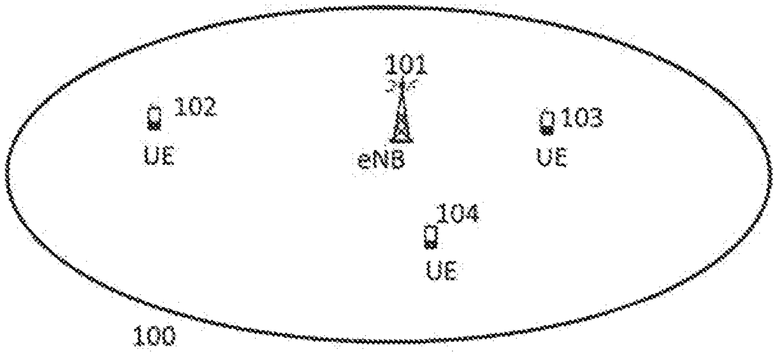

Fig. 1D

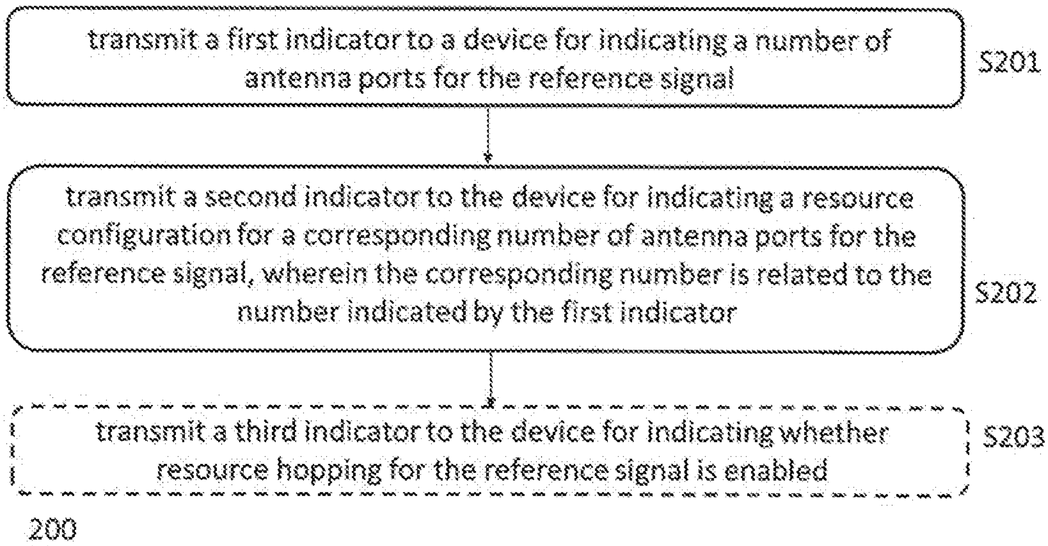

Fig. 2A

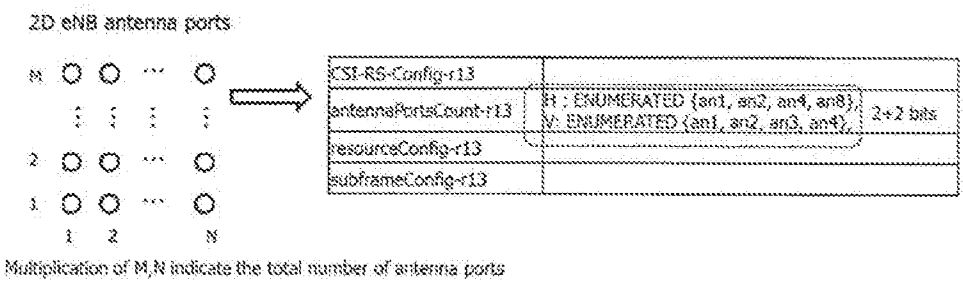

Fig. 2B

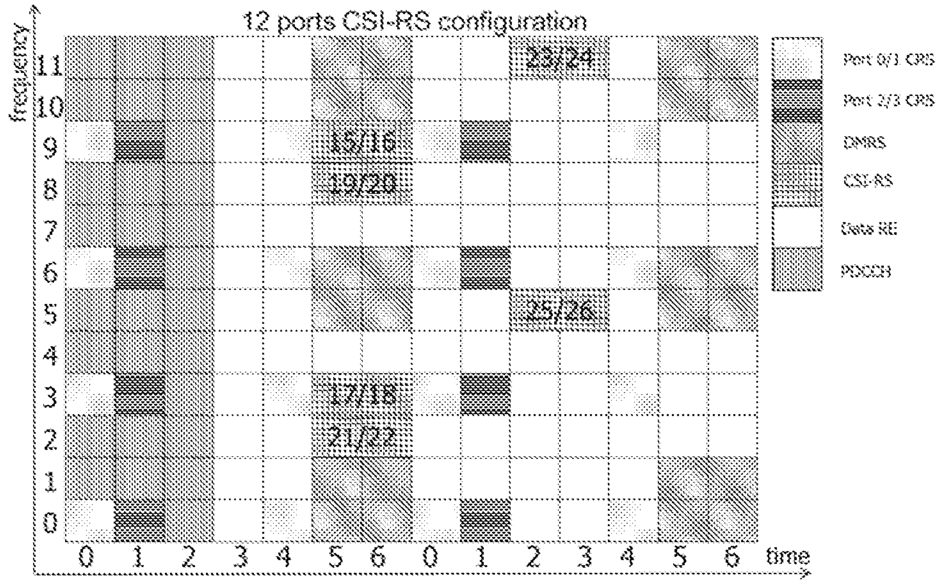
12 ports CSI-RS configuration
frequency
time
23/24
15/16
19/20
25/26
17/18
21/22
Port 0/1 CRS
Port 2/3 CRS
DMRS
CSI-RS
Data RE
PDCCH

Fig. 3A

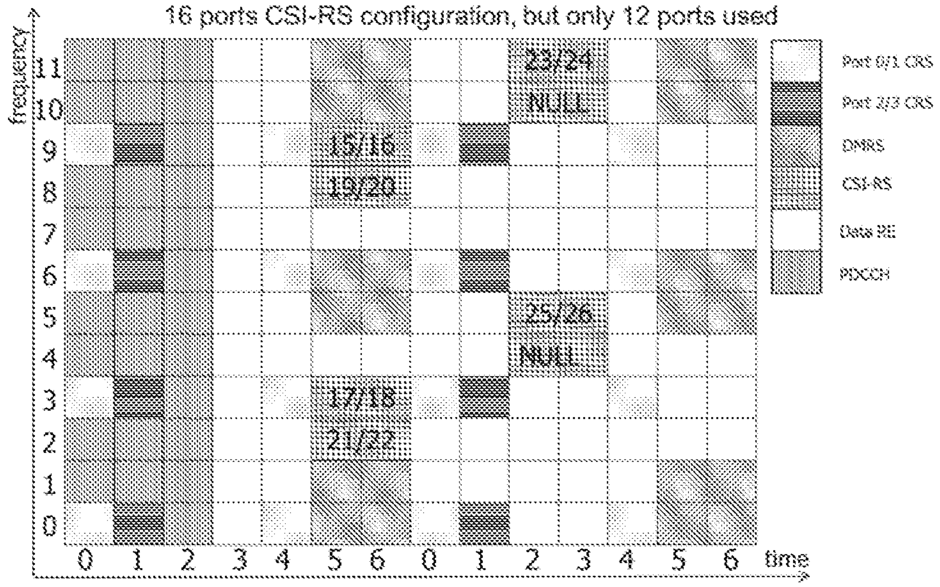
16 ports CSI-RS configuration, but only 12 ports used
frequency
time
23/24
NULL
15/16
19/20
25/26
NULL
17/18
21/22
Port 0/1 CRS
Port 2/3 CRS
DMRS
CSI-RS
Data RE
PDCCH

Fig.3B

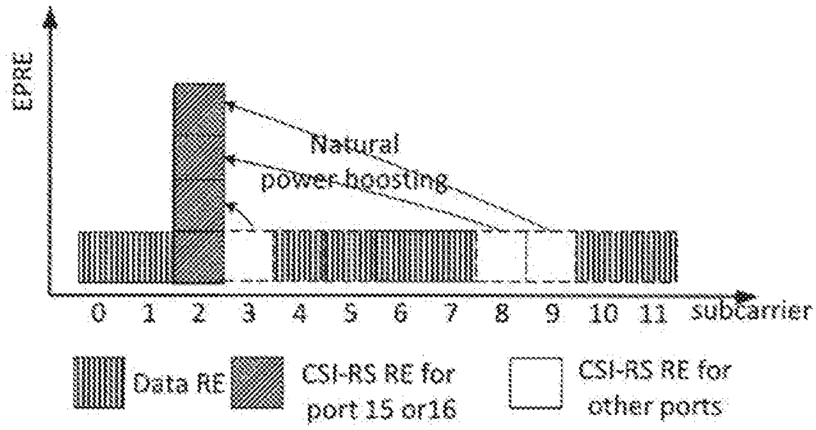
EPRE
Natural
power boosting
0 1 2 3 4 5 6 7 8 9 10 11 subcarrier
Data RE
CSI-RS RE for
port 15 or16
CSI-RS RE for
other ports

Fig. 3C

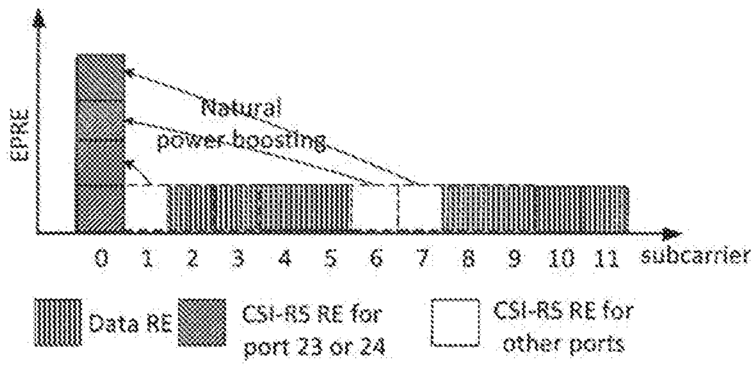
EPRE
Natural
power boosting
0 1 2 3 4 5 6 7 8 9 10 11 subcarrier
Data RE
CSI-RS RE for
port 23 or 24
CSI-RS RE for
other ports

Fig. 3D

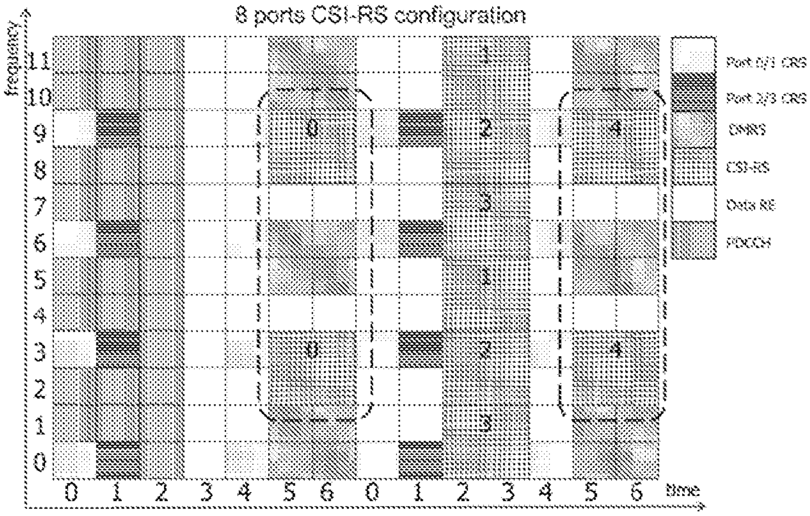

Fig.4A

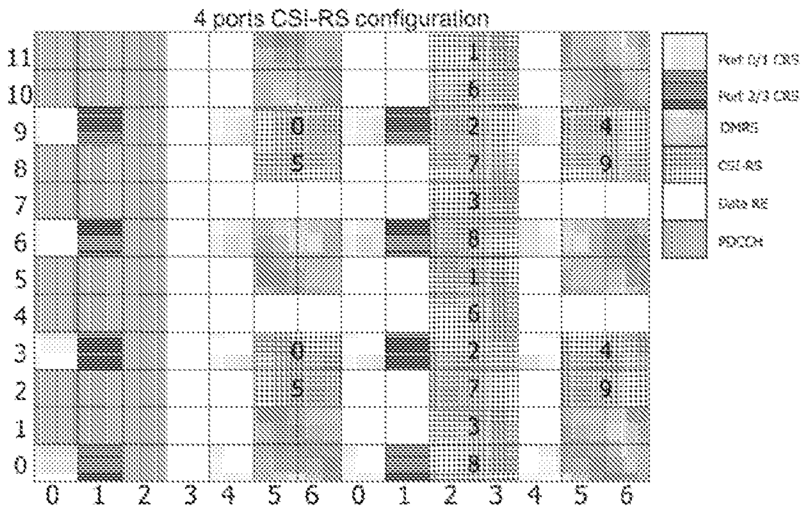

Fig.4B

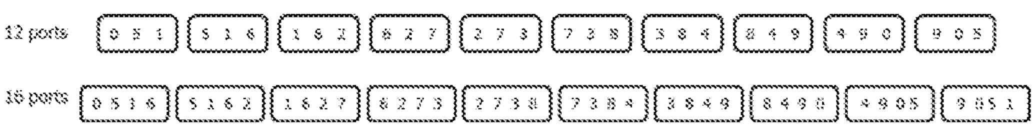

Fig.4C

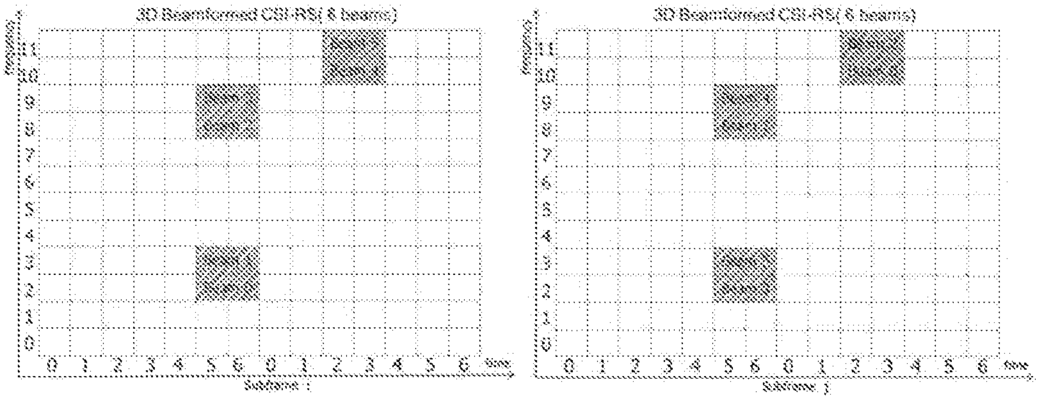

Fig.5A

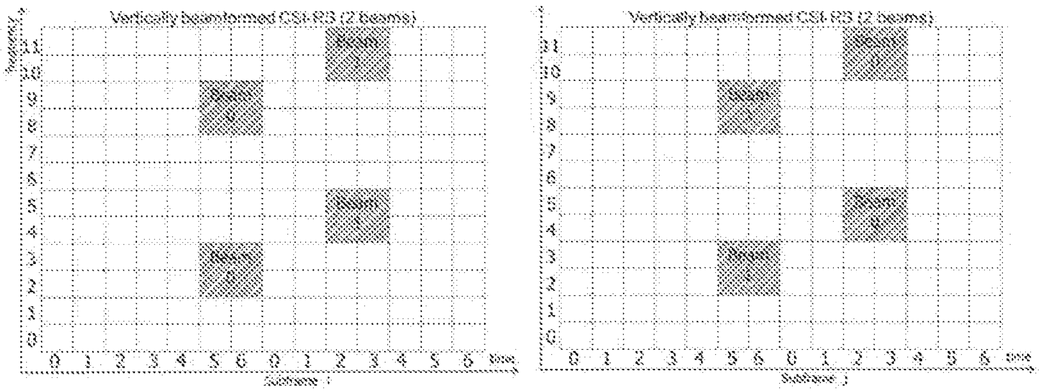

Fig.5B

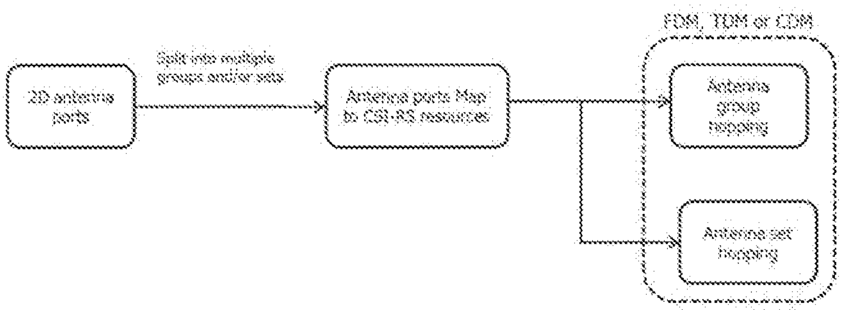

Fig.6A

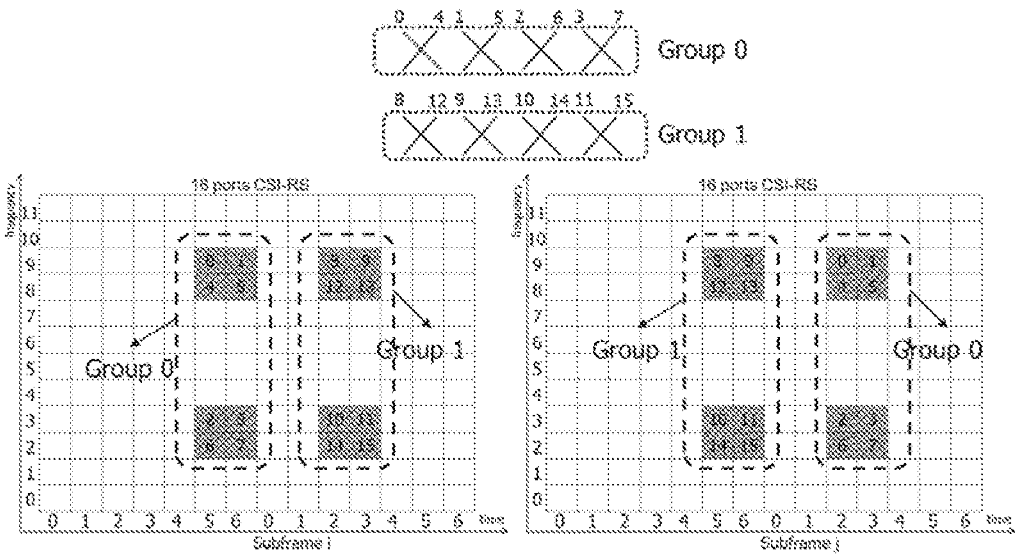
Group 0
Group 1
16 ports CSI-RS
Group 0
Group 1
Subframe i
16 ports CSI-RS
Group 1
Group 0
Subframe j

Fig.6B

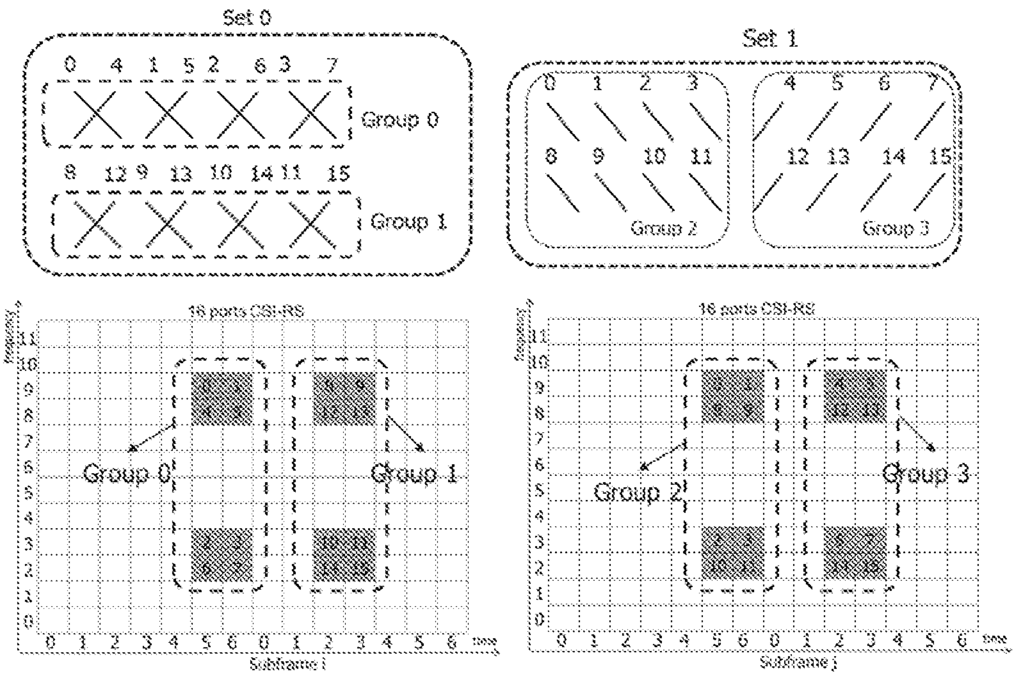
Set 0
Group 0
Group 1
Set 1
Group 2
Group 3
16 ports CSI-RS
Group 0
Group 1
Subframe i
16 ports CSI-RS
Group 2
Group 3
Subframe j

Fig.6C

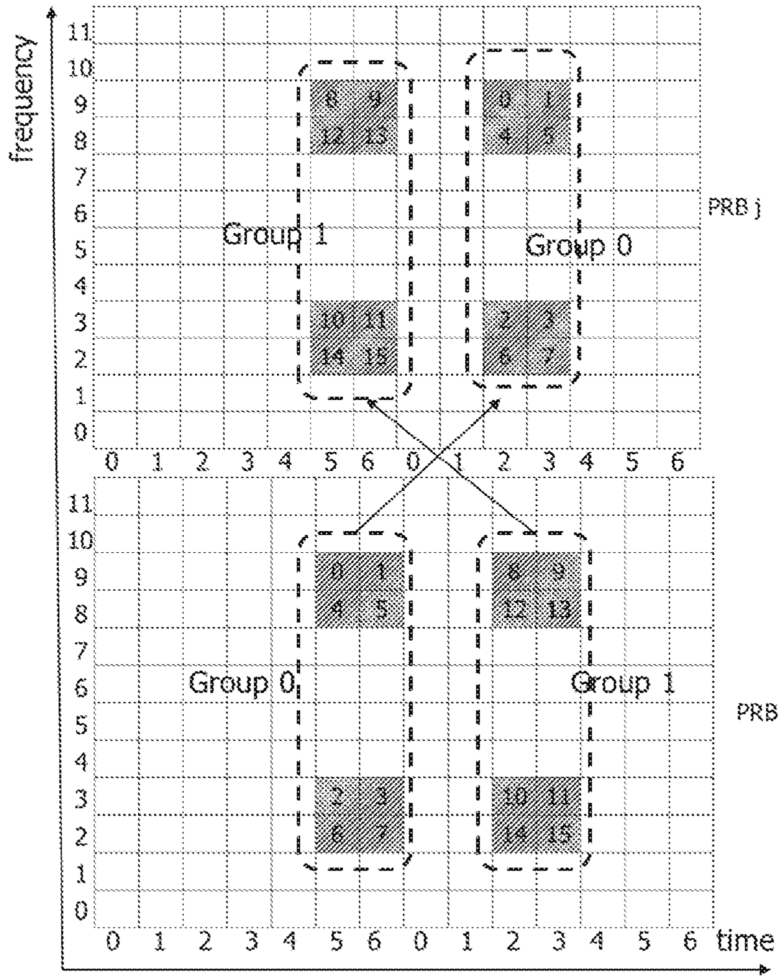

Fig.6D

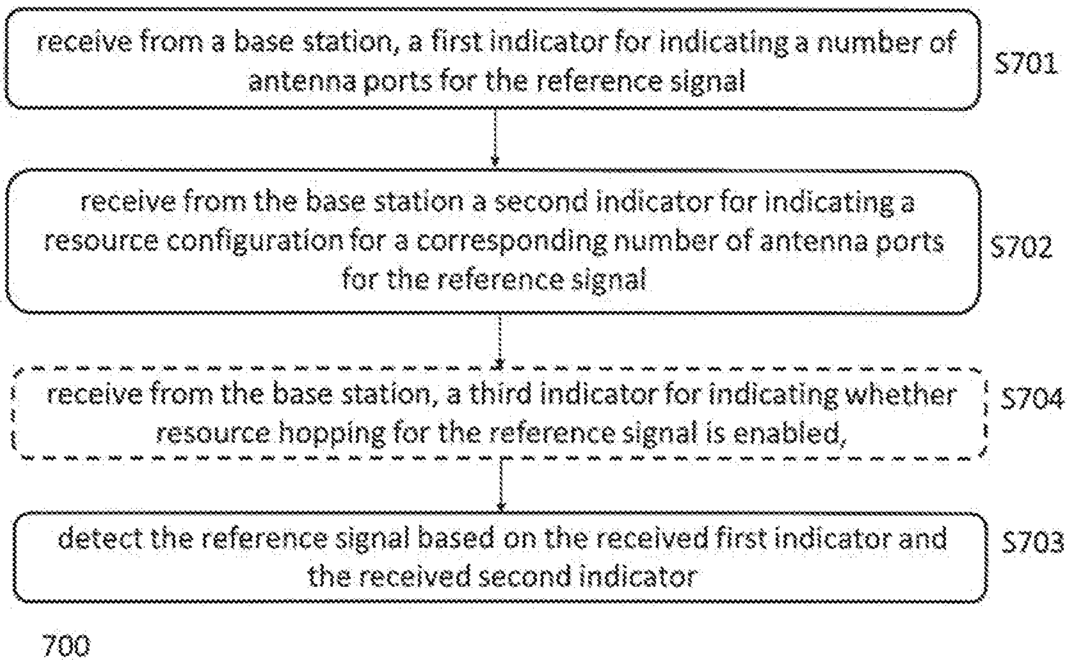

Fig.7

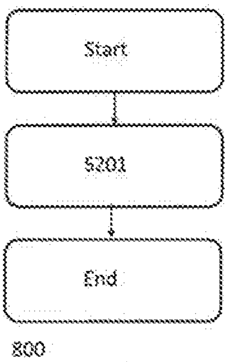

Fig. 8A

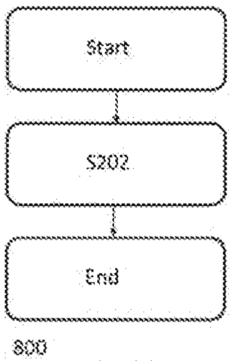

Fig. 8B

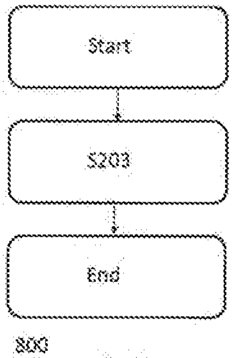

Fig. 8C

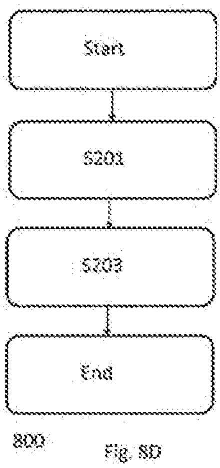

Fig. 8D

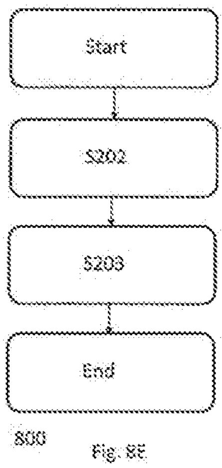

Fig. 8E

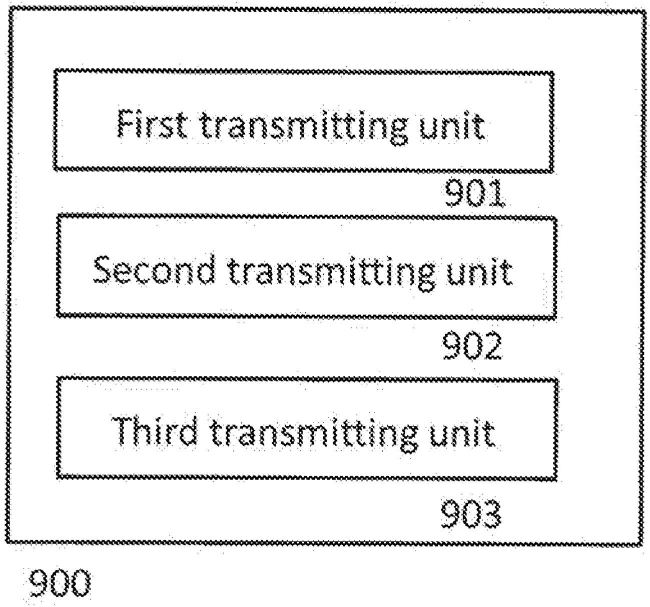
First transmitting unit
901
Second transmitting unit
902
Third transmitting unit
903
900

Fig. 9

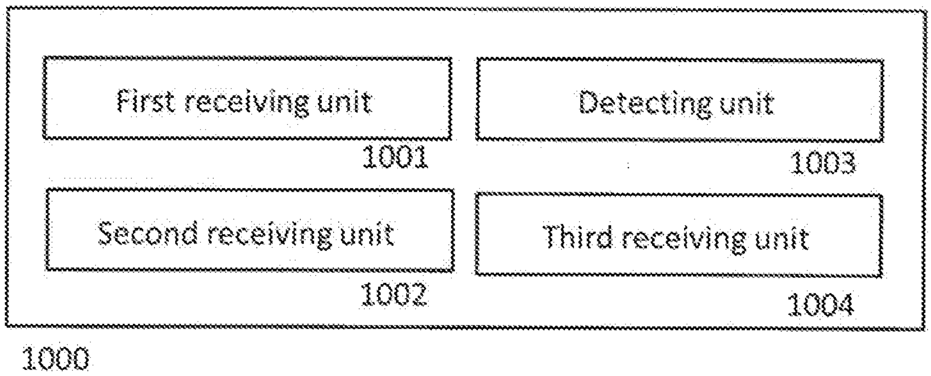
First receiving unit
1001
Detecting unit
1003
Second receiving unit
1002
Third receiving unit
1004
1000

Fig. 10

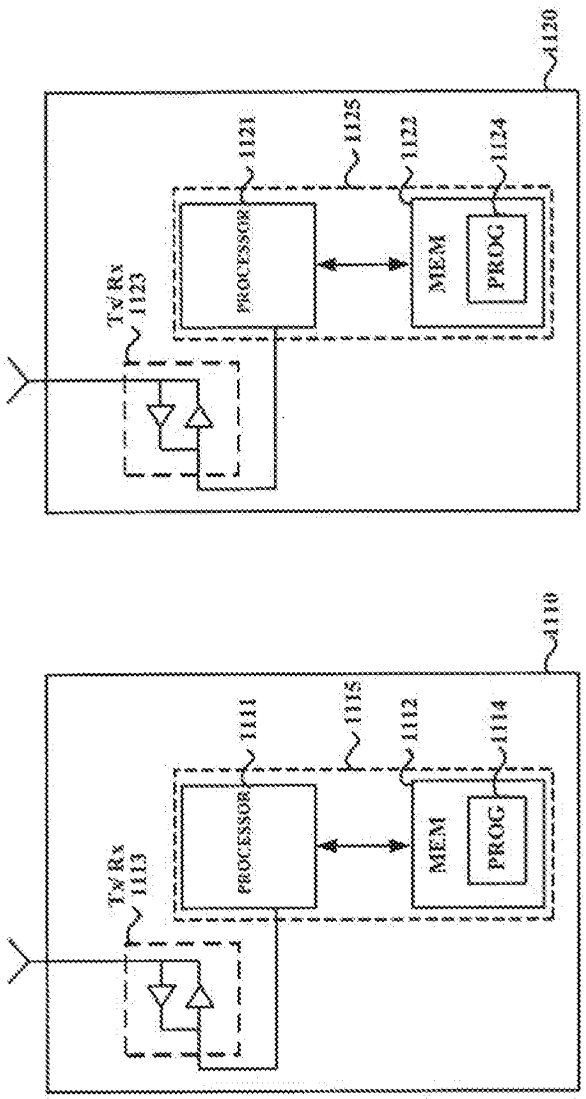
1120
1121
1125
1122
1124
PROCESSOR
MEM
PROG
Tx/ Rx
1123
1110
1111
1115
1112
1114
PROCESSOR
MEM
PROG
Tx/ Rx
1113

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/083946

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/04(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B; H04W; H04Q; H04L

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

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

CNPAT, CNKI, EPODOC, WPI, IEEE: antenna port, indicator, resource configuration, beamforming, resource hopping pattern, reference signal.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 20140057005 A (PANTECH CO., LTD.) 12 May 2014 (2014-05-12) description, paragraphs [0175]-[0176]	1-30
A	CN 104428998 A (LG ELECTRONICS INC.) 18 March 2015 (2015-03-18) the whole document	1-30
A	CN 104521318 A (SHARP CORPORATION) 15 April 2015 (2015-04-15) the whole document	1-30
A	US 2013329543 A1 (PANASONIC CORPORATION) 12 December 2013 (2013-12-12) the whole document	1-30

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
24 February 2016	**25 March 2016**

Name and mailing address of the ISA/CN	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/083946

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
KR	20140057005	A	12 May 2014	WO	2014069821	A1	08 May 2014
				US	2015288497	A1	08 October 2015
CN	104428998	A	18 March 2015	US	2015162966	A1	11 June 2015
				EP	2869478	A1	06 May 2015
				WO	2014007512	A1	09 January 2014
				KR	20150035555	A	06 April 2015
				IN	2949KONP2014	A	08 May 2015
				WO	2013187739	A1	19 December 2013
				KR	20130141382	A	26 December 2013
				CN	104365136	A	18 February 2015
				EP	2863679	A1	22 April 2015
				US	2015131568	A1	14 May 2015
				JP	2015519855	A	09 July 2015
CN	104521318	A	15 April 2015	EP	2882254	A1	10 June 2015
				WO	2014021391	A1	06 February 2014
				AU	2013297445	A1	19 February 2015
				US	2015195732	A1	09 July 2015
US	2013329543	A1	12 December 2013	WO	2012147273	A1	01 November 2012
				JPWO	2012147273	A1	28 July 2014