



(51) International Patent Classification:

H04B 7/0456 (2017.01) **H04L 5/00** (2006.01)
H04B 7/06 (2006.01)

(21) International Application Number:

PCT/IB2017/000462

(22) International Filing Date:

31 March 2017 (31.03.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

201610196814.6 31 March 2016 (31.03.2016) CN

(71) **Applicant:** **ALCATEL LUCENT** [FR/FR]; 148/152
Route de la Reine, 92100 BOULOGNE-BILLANCOURT
(FR).

(72) **Inventors:** **LI, Xun**; Alcatel-Lucent Shanghai Bell Co.,
Ltd., 388 Ningqiao Road, PuDong Jinqiao, SHANGHAI,
201206 (CN). **YANG, Tao**; Alcatel-Lucent Shanghai Bell
Co., Ltd., 388 Ningqiao Road, PuDong Jinqiao, SHANG-
HAI, 201206 (CN). **ZHANG, Min**; Alcatel-Lucent Shang-
hai Bell Co., Ltd., 388 Ningqiao Road, PuDong Jinqiao,
SHANGHAI, 201206 (CN).

(74) **Agent:** **BERTHIER, Karine**; ALCATEL-LUCENT IN-
TERNATIONAL, 148/152 route de la Reine, 92100
Boulogne-Billancourt (FR).

(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, DJ, 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, KH, KN,
KP, KR, KW, 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 DETERMINING CHANNEL INFORMATION

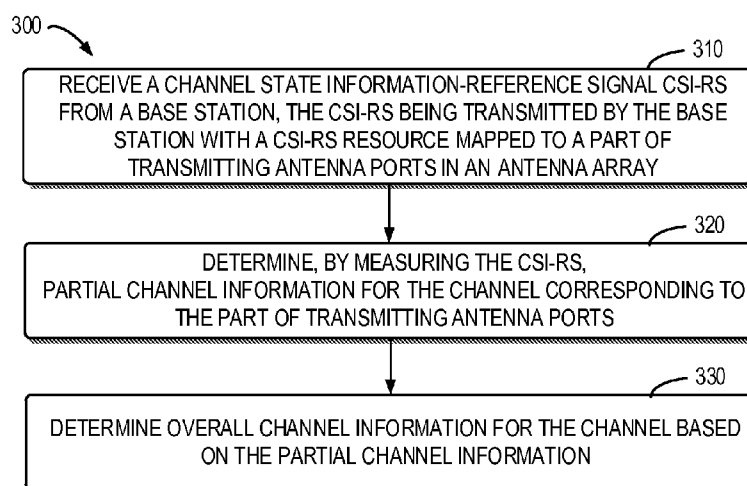


FIG. 3

(57) **Abstract:** Embodiments of the present disclosure provide a method and an apparatus of determining channel information for a channel. The method comprises receiving a channel state information-reference signal (CSI-RS) from a base station, the CSI-RS being transmitted by the base station with a CSI-RS resource mapped to a part of transmitting antenna ports in an antenna array. The method further comprises determining, by measuring the CSI-RS, partial channel information for the channel corresponding to the part of transmitting antenna ports. In addition, the method further comprises determining overall channel information for the channel based on the partial channel information.

METHOD AND APPARATUS FOR DETERMINING CHANNEL INFORMATION

FIELD

[0001] Embodiments of the present disclosure generally relate to the field of wireless communication, and more specifically, to a method and an apparatus for determining channel information.

BACKGROUND

[0002] Two-dimensional (2D) Multiple Input Multiple Output (MIMO) transmission has been studied and adopted in Long Term Evolution (LTE) system, where conventional antenna arrays are arranged horizontally to form a beam in a horizontal plane. Moreover, there is also proposed a three-dimensional (3D) MIMO channel transmission model at present. To explore more potential gain from a 3D wireless channel, 2D active antenna array system has been used to form a 3D beam in both vertical and horizontal planes.

[0003] However, in a traditional scheme, channel state information-reference signal (CSI-RS) resources are limited to perform full-port mapping for the transmitting antenna. The full-port mapping means that the number of CSI-RS resources is equal to the number of transmitting antenna ports. To obtain complete channel information of the wireless communication channel, each of the CSI-RS resources mapped to each of the transmitting antenna ports is required for transmitting a respective CSI-RS. Therefore, the full-port mapping may enable a user equipment to determine channel information of the wireless communication channel more easily, but thereby introducing significant overhead for CSI-RS transmission. Furthermore, with an increase of the number of transmitting antenna ports (for example, increasing from up to 16 transmitting antenna ports at present to 32 transmitting antenna ports desired by the 3D MIMO transmission), the overhead for CSI-RS transmission would be more significant. The traditional scheme cannot reduce the overhead for CSI-RS transmission efficiently.

SUMMARY

[0004] Embodiments of the present disclosure described herein provide a method and an apparatus of determining channel information for a channel.

[0005] In accordance with the first aspect of the present disclosure described herein, there is

provided a method of determining channel information for a channel. The method comprises receiving a channel state information-reference signal CSI-RS from a base station, the CSI-RS being transmitted by the base station with a CSI-RS resource mapped to a part of transmitting antenna ports in an antenna array. The method further comprises determining, by measuring the CSI-RS, partial channel information for the channel corresponding to the part of transmitting antenna ports. In addition, the method further comprises determining overall channel information for the channel based on the partial channel information.

[0006] In accordance with the second aspect of the present disclosure described herein, there is provided an apparatus of determining channel information for a channel. The apparatus comprises a reference signal receiving module configured to receive a channel state information-reference signal CSI-RS from a base station, the CSI-RS being transmitted by the base station with a CSI-RS resource mapped to a part of transmitting antenna ports in an antenna array. The apparatus further comprises a partial channel information determining module configured to determine, by measuring the CSI-RS, partial channel information for the channel corresponding to the part of transmitting antenna ports. In addition, the apparatus further comprises an overall channel information determining module configured to determine overall channel information for the channel based on the partial channel information.

[0007] Embodiments of the present disclosure described herein enable estimation of channel information based on a partial port mapping method, thereby reducing CSI-RS transmission overhead during this process efficiently.

[0008] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed present disclosure, nor is it intended to be used to limit the scope of the claimed present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Through the following detailed description with reference to the accompanying drawings, the above and other objectives, features, and advantages of example embodiments of the present disclosure will become more apparent, where in the example embodiments, the same reference symbols refer to the same elements.

[0010] FIG. 1 is a schematic diagram illustrating an environment 100 in which embodiments of the present disclosure can be implemented;

[0011] FIG. 2 is an exemplary schematic diagram illustrating an antenna array 200 in the base station 110 as shown in FIG. 1.

[0012] FIG. 3 is a flowchart of a method 300 of determining channel information for a channel according to embodiments of the present disclosure;

5 [0013] FIG. 4 is a schematic diagram illustrating determining the overall channel information of channels based on the partial channel information according to embodiments of the present disclosure;

[0014] FIG. 5 is a schematic diagram illustrating determining the overall channel information of channels based on the partial channel information according to embodiments
10 of the present disclosure;

[0015] FIG. 6 is a schematic diagram illustrating determining the overall channel information of channels based on the partial channel information according to embodiments of the present disclosure;

[0016] FIG. 7 is a schematic diagram illustrating determining the overall channel
15 information of channels based on the partial channel information according to embodiments of the present disclosure;

[0017] FIG. 8 is a schematic diagram illustrating determining the overall channel information of channels based on the partial channel information according to embodiments of the present disclosure;

20 [0018] FIG. 9 is a schematic diagram illustrating determining the overall channel information of channels based on the partial channel information according to embodiments of the present disclosure;

[0019] FIG. 10 is a schematic diagram illustrating determining the overall channel information of channels based on the partial channel information according to embodiments
25 of the present disclosure;

[0020] FIG. 11 is a block diagram of an apparatus 1100 of determining channel information for a channel according to embodiments of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0021] Preferred embodiments of the present disclosure will be described as follows in
30 greater detail with reference to the drawings. Although preferred embodiments of the

present disclosure are illustrated in the drawings, it is to be understood that the present disclosure described herein can be implemented in various manners, not limited to the embodiments illustrated herein. Rather, these embodiments are provided to make the present disclosure described herein clearer and more complete and convey the scope of the present disclosure described herein completely to those skilled in the art.

[0022] As used herein, the term “includes” and its variants are to be read as open-ended terms that mean “includes, but is not limited to.” The term “or” is to be read as “and/or” unless the context clearly indicates otherwise. The term “based on” is to be read as “based at least in part on.” The term “one example implementation” and “an example implementation” are to be read as “at least one example implementation.” The term “another implementation” is to be read as “at least one other implementation.” Terms “a first”, “a second” and others can denote different or identical objects. The following text may also contain other explicit or implicit definitions.

[0023] In some embodiments of the present disclosure, the term “CSI-RS resource” represents time domain and/or frequency domain resources for transmitting CSI-RS. The term “CSI-RS configuration resource” represents a collection of a plurality of CSI-RS resources. The term “CSI process” represents a process triggered by a base station to obtain channel state information (CSI). The CSI process can be periodic, and different CSI processes can be configured with different transmission periodicities respectively.

[0024] In the traditional scheme, in order to obtain a large number of antenna ports (for example, 12, 16) by expanding a small number of antenna ports (for example, 1, 2, 4 or 8), it is usually necessary to aggregate CSI-RS resources. The CSI-RS resource aggregation means aggregating several CSI-RS resources corresponding to fewer antenna ports to form a new CSI-RS resource corresponding to more antenna ports. This method is called full-port mapping-based method, which implies that the CSI-RS resources and the transmitting antenna ports are in a relationship of one-to-one mapping.

[0025] However, for the current LTE standard (for example, version 13), the total number of available CSI-RS resource elements is 40. These CSI-RS resource elements will be used for both of channel information estimation and interference measurement. The number of transmitting antenna ports expected by the 3D MIMO transmission is 32, which means that there are no sufficient CSI-RS resource elements for interference measurement if the full-port mapping-based method is used to achieve channel information estimation. In other words,

the high overhead for CSI-RS transmission introduced by the full-port mapping-based method makes it difficult to perform both of channel information estimation and interference measurement at the same time.

[0026] To solve the above problem and one or more of the other potential problems, according to embodiments of the present disclosure, there is provided a scheme for determining channel information. The scheme achieves estimation of channel information based on a partial port mapping method, thereby efficiently reducing the overhead for CSI-RS transmission during this process.

[0027] FIG. 1 is a schematic diagram illustrating an environment 100 in which embodiments of the present disclosure can be implemented. As shown in FIG. 1, the environment 100 may include a base station 110 and a UE 120, both of which communicate via a wireless communication channel. The base station 110, for instance, may include an evolved NodeB (eNB) in the LTE system. In the context of the present disclosure, a base station (BS) may represent a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), a remote radio unit (RRU), a radio header (RH), a remote radio head (RRH), a relay, a low power node, such as a pico station and a femto station, and the like. A “User equipment” (UE) may refer to any device that can communication with a BS. As an example, a UE may refer to a terminal, a mobile terminal (MT), a subscriber station (SS), a portable subscriber station (PSS), a mobile station (MS), or an access terminal (AT).

[0028] To obtain channel state information (CSI) of the wireless communication channel, the base station 110 may transmit a CSI-RS to the UE 120. The UE 120 may receive the CSI-RS from the base station 110, and determine channel information for the channel by measuring the CSI-RS. The channel information may describe an attenuation factor of the signal on each of transmission paths of the channel. Based on the channel information, the UE 120 may use a corresponding codebook to obtain the CSI of the channel and transmit the CSI to the base station 110. The CSI may ensure reliability of the wireless communication between the base station 110 and the UE 120. In this description, the above process is referred to as a “CSI process”.

[0029] The base station 110 may usually have a plurality of transmitting antennas which may form a 2D active antenna array. The base station 110 may transmit the CSI-RS to the UE 120 with CSI-RS resources mapped to antenna ports in the antenna array. Each of transmitting antenna ports corresponds to a transmission path for the signal. Therefore, to

reconstruct the overall wireless channel (that is, to obtain a respective attenuation factor on each of the transmission paths), the UE 120 may need to determine an overall channel information corresponding to all of the transmitting antenna ports.

[0030] FIG. 2 is an exemplary schematic diagram illustrating an antenna array 200 in the base station 110 as shown in FIG. 1. As shown in FIG. 2, for example, the antenna array 200 is composed of dual polarized (that is, vertically polarized and horizontally polarized) $M \times N$ transmission antennas. Therefore, the antenna array 200 may have $2MN$ transmitting antenna ports in total. If the transmitting antenna ports in one of two polarizations (that are, vertical polarization and horizontal polarization) among these transmitting antenna ports are numbered column by column and then the transmitting antenna ports in the other of the two polarizations among these transmitting antenna ports are numbered column by column, then the overall channel information to be determined by the UE 120, which corresponds to all of the transmitting antenna ports, can be represented as $H=[h_1, h_2, \dots, h_{2MN}]$, where H represents the overall channel information of the channel, and h_n ($n = 1, 2, \dots, 2MN$) represents the channel information corresponding to the n^{th} transmitting antenna port.

[0031] FIG. 3 is a flowchart of a method 300 of determining channel information for a channel according to embodiments of the present disclosure. In the following description, the method 300 will be described with reference to the environment 100 as shown in FIG. 1 and the antenna array 200 as shown in FIG. 2. For instance, the method 300 may be implemented by the UE 120 as shown in FIG. 1. It is to be understood that the method 300 may further include additional acts not shown and/or omit some acts as shown. The scope of the present disclosure is not limited in this respect.

[0032] In block 310, CSI-RS is received by the UE 120 from the base station 110. The CSI-RS may be transmitted by the base station 110 with a CSI-RS resource mapped to a part of transmitting antenna ports in the antenna array 200.

[0033] In block 320, the UE 120 determines partial channel information for the channel corresponding to the part of transmitting antenna ports by measuring the CSI-RS. For instance, the partial channel information can be represented as $\overline{h_1}, \overline{h_2}, \dots, \overline{h_K}$.

[0034] In block 330, the UE 120 determines overall channel information for the channel based on the partial channel information. For instance, in some embodiments, the overall channel information H for the channel can be calculated as the following equation (1):

$$H = \zeta(\overline{h_1}, \overline{h_2}, \dots, \overline{h_K}) \quad (1)$$

where $\zeta(\cdot)$ represents a reconstruction function for the partial channel information, which may include linear combination operation, product operation (for example, Kronecker product operation) and so on.

[0035] Merely for the purpose of illustration and demonstration, method 300 will be further described in the following description in detail with reference to some specific embodiments. In one embodiment, the UE 120 may receive, from the base station 110, the CSI-RS which may be transmitted (310) by the base station 110 with first and second CSI-RS resources.

The first CSI-RS resource may be mapped to a column of transmitting antenna ports in the antenna array 200, and the second CSI-RS resource may be mapped to a row of transmitting antenna ports in the antenna array 200. Therefore, the UE 120 may determine, by measuring the CSI-RS, the first partial channel information $\overline{h_1}$ corresponding to the column of transmitting antenna ports and the second partial channel information $\overline{h_2}$ corresponding to the row of transmitting antenna ports.

[0036] Next, the UE 120 may determine (330) the overall channel information H by calculating the product (for example, Kronecker product) of the first partial channel information $\overline{h_1}$ and the second partial channel information $\overline{h_2}$. For instance, FIG. 4 is a schematic diagram illustrating determining the overall channel information for the channel based on the partial channel information according to embodiments of the present disclosure.

As shown in FIG. 4, $\overline{h_1} = [h_1, h_2, \dots, h_M]$ and $\overline{h_2} = [h_1, h_{M+1}, \dots, h_{(2N-1)M+1}]$. The overall channel information H can be calculated as the following equation (2):

$$H = \overline{h_2} \otimes \overline{h_1} \quad (2)$$

In this embodiment, if the first and second CSI-RS resources are included in the same CSI-RS configuration resource, then the total number of CSI-RSs transmitted with the first and second CSI-RS resources is $M+2N-1$ (smaller than the total number of antenna ports $2MN$). If the first and second CSI-RS resources are included in different CSI-RS configuration resources, the total number of CSI-RSs transmitted with the first and second CSI-RS

resources is $M+2N$ (also smaller than the total number of antenna ports $2MN$).

[0037] In another embodiment, the UE 120 may receive, from the base station 110, the CSI-RS which may be transmitted by the base station 110 with third, fourth and fifth CSI-RS resources (310). The third CSI-RS resource may be mapped to a row of transmitting antenna ports in the antenna array 200. The fourth CSI-RS resource may be mapped to a first group of a column of transmitting antenna ports in one of two polarizations. The fifth CSI-RS resource may be mapped to a second group of the column of transmitting antenna ports in the other of the two polarizations. As such, the UE 120 can determine a third partial channel information $\overline{h_3}$ corresponding to the row of transmitting antenna ports, a fourth partial channel information $\overline{h_4}$ corresponding to the first group of transmitting antenna ports and a fifth partial channel information $\overline{h_5}$ corresponding to the second group of transmitting antenna ports (320).

[0038] Then, the UE 120 may determine the overall channel information H based on a product of the third partial channel information $\overline{h_3}$, the fourth partial channel information $\overline{h_4}$ and a fifth partial channel information $\overline{h_5}$ (330). For example, in some embodiments, a Kronecker product can be applied. It is to be understood that this is only an example. Any product operation currently known or to be studied in the future can be utilized in combination with the embodiments of the present disclosure.

[0039] For instance, FIG. 5 is a schematic diagram illustrating determining the overall channel information of channels based on the partial channel information according to embodiments of the present disclosure. As shown in FIG. 5, $\overline{h_4} = [h_1, h_2, \dots, h_M]$, $\overline{h_5} = [h_{MN+1}, h_{MN+2}, \dots, h_{MN+M}]$ and $\overline{h_3} = [h_1, h_{M+1}, \dots, h_{(N-1)M+1}]$. Then the overall channel information H can be calculated as the following equation (3):

$$H = (\overline{h_3} \otimes \overline{h_4}) + (\overline{h_3} \otimes \overline{h_5}) \quad (3)$$

In this embodiment, if the third, fourth and fifth CSI-RS resources are included in the same CSI-RS configuration resource, the total number of CSI-RSs transmitted with the third, fourth and fifth CSI-RS resources is $2M+N-1$ (smaller than the total number of antenna ports $2MN$). If the third, fourth and fifth CSI-RS resources are included in different CSI-RS

configuration resources, the total number of CSI-RS transmitted with the third, fourth and fifth CSI-RS resources is $2M+N$ (also smaller than the total number of antenna parts $2MN$).

[0040] Alternatively or additionally, in yet another implementation, the UE 120 may receive, from the base station 110, the CSI-RS which is transmitted by the base station 110 with a sixth CSI-RS resource mapped to a third group of transmitting antenna ports and a seventh CSI-RS resource mapped to a fourth group of transmitting antenna ports (310). The third group of transmitting antenna ports are distributed in a first antenna block of the antenna array 200 and the fourth group of transmitting antenna ports are distributed in a second antenna block of the antenna array 200, where the first antenna block is larger than the second antenna block. As such, the UE 120 may determine the sixth partial channel information $\overline{h}_6$ corresponding to the third group of antenna ports and the seventh partial channel information $\overline{h}_7$ corresponding to the fourth group of transmitting antenna ports (320).

[0041] Next, the UE 120 may determine the overall channel information H by calculating the product (for example, Kronecker product) of the sixth partial channel information $\overline{h}_6$ and the seventh partial channel information $\overline{h}_7$ (330). For instance, FIG. 6 is a schematic diagram illustrating determining the overall channel information of channels based on the partial channel information according to embodiments of the present disclosure. As shown in FIG. 6, the overall channel information H can be calculated in accordance with the following equation (4):

$$H = \overline{h}_6 \otimes \overline{h}_7 \quad (4)$$

In this embodiment, if the sixth and seventh CSI-RS resources are included in the same CSI-RS configuration resource, the total number of CSI-RSs transmitted with the sixth and seventh CSI-RS resources is $2M'N'+MN/M'N'-1$ (smaller than the total number of antenna ports $2MN$), where M' indicates the number of antenna blocks divided in each column, N' indicates the number of antenna blocks divided in each row, and both M' and N' are greater than or equal to 1. If the sixth and seventh CSI-RS resources are included in different CSI-RS configuration resources, the total number of CSI-RSs transmitted with the sixth and seventh CSI-RS resources is $2M'N'+MN/M'N'$ (also smaller than the total number of antenna ports $2MN$).

[0042] In yet another implementation, the UE 120 may receive, from the base station 110,

the CSI-RS which is transmitted by the base station 110 with a plurality of groups of CSI-RS resources mapped to a plurality of transmitting antenna ports respectively (310). Each of the plurality of groups of transmitting antenna ports may include a column of transmitting antenna ports, a row of transmitting antenna ports, a block of transmitting antenna ports or interleaved transmitting antenna ports. As such, the UE 120 may determine a plurality of partial channel information $\overline{h_1}$, $\overline{h_2}$, $\overline{h_3}$... corresponding to the plurality of groups of transmitting antenna ports, respectively (320). Next, the UE 120 may determine the overall channel information H by applying linear combination to the plurality of partial channel information $\overline{h_1}$, $\overline{h_2}$, $\overline{h_3}$... (330). For instance, the overall channel information H can be calculated as the following equation (5):

$$H = \overline{h_1} + \overline{h_2} + \overline{h_3} + \dots \quad (5)$$

where $\overline{h_k}$ may have the same dimension as H, and only an element of $\overline{h_k}$ which corresponds to the subset of transmitting antenna ports (that is, one of the plurality of groups of transmitting antenna ports) may have a value for the channel information (for example, h_{CSI-RS}) determined by measuring the CSI-RS, and the value of any of other elements may be 0. In other words, $\overline{h_k}$ may be represented in the following equation (6):

$$\overline{h_k} = [h_k^{1,1}, h_k^{2,1}, \dots, h_k^{m,n}, \dots, h_k^{M,2N}] \quad (6)$$

$$h_k^{m,n} = \begin{cases} h_{CSI-RS} & \text{antenna port subset} \\ 0 & \text{otherwise} \end{cases}$$

[0043] For example, FIG. 7-FIG. 10 each illustrate a schematic diagram illustrating determining the overall channel information of channels based on the partial channel information according to embodiments of the present disclosure. In FIG. 7, each of the plurality of groups of transmitting antenna ports includes a row of transmitting antenna ports. In FIG. 8, each of the plurality of groups of transmitting antenna ports includes a column of transmitting antenna ports. In FIG. 9, each of the plurality of groups of transmitting antenna ports includes a block of transmitting antenna ports. In FIG. 10, each of the plurality of groups of transmitting antenna ports include interleaved transmitting antenna ports.

[0044] Furthermore, for determining the overall channel information by linear combination as applied above, in other embodiments, the overall channel information may also be determined at the base station side. Additional inter-subset pre-code matrix indication (PMI) may be fed back from UE to the base station to indicate the correlation between the subsets.

At the UE side, PMI_k may indicate the PMI selected from a codebook with partial channel information from a subset of transmitting antenna ports k and the codeword may be represented as $\tilde{h}_k$. PMI_{inter} may indicate channel information between subsets of transmitting antenna ports, which can be the first or other transmitting antenna port from each of the subsets. The codeword can be represented as $\tilde{h}_{inter}$. Therefore, at the base station side, the overall channel information H can be represented as the following equation (7):

$$H = \tilde{h}_{inter}^1 \overline{h_1} + \tilde{h}_{inter}^2 \overline{h_2} + \tilde{h}_{inter}^3 \overline{h_3} + \tilde{h}_{inter}^4 \overline{h_4} + \dots \quad (7)$$

$$\overline{h_k} = [h_k^{1,1}, h_k^{2,1}, \dots, h_k^{m,n}, \dots, h_k^{M,2N}]$$

$$h_k^{m,n} = \begin{cases} \tilde{h}_k^{i,j} & \text{antenna port subset} \\ 0 & \text{otherwise} \end{cases}$$

where index (m, n) may represent an index for an antenna port in the antenna array, index (i, j) may indicate a corresponding result of channel measurement in a subset of antenna ports and $\tilde{h}_{inter}^i$ may indicate the i^{th} element of codeword $\tilde{h}_{inter}$.

[0045] In some embodiments, the method 300 may further include optional additional acts. For instance, in some embodiments, after the block 330 is implemented, the UE 120 may further determine a first CSI corresponding to the partial channel information and transmit the first CSI to the base station 110. The first CSI, for example, may include PMI and the like. The codebook used for the PMI feedback may support the number of the part of transmitting antenna ports. The feedback of corresponding narrow band channel quality indication (CQI) and rank indication (RI) may be calculated based on the partial channel information determined by each of CSI processes and transmitted to the base station 110.

[0046] Additionally or alternatively, the UE 120 may further determine a second CSI corresponding to the overall channel information and transmit the second CSI back to the base station 110. The second CSI, for instance, may include PMI, CQI, RI and so on. The codebook for the PMI feedback may support the number of all of transmitting antenna ports. Since different CSI processes can be configured with different periodicities, when the UE 120 is configured to transmit the second CSI corresponding to the overall channel information, the speed rate for the feedback can be the same as the CSI-RS transmission in a short periodicity, while the channel information determined from the CSI-RS transmission in a long periodicity will be reused until the channel information is updated.

[0047] In some embodiments, the CSI feedback can be configured as such a process that combines a full-port mapping-based CSI process in a long periodicity and a partial-port mapping-based CSI process in a short periodicity. In case that the overall information is reconstructed and applied at the UE 120 side, the UE 120 may feedback the CSI based on the reconstructed channel information, which can be represented as the following equation (8):

$$H(t_2) = H(t_1)\delta\{\overline{h_1}(t_1), \overline{h_1}(t_2)\} \quad (8)$$

where $H(t)$ may represent the overall channel information at timeslot (frame) t , $\delta\{\cdot\}$ may represent a channel updating function based on partial channel information for one or more groups of antenna ports at timeslot t_1 and timeslot t_2 . An example may be represented as the following equation (9), where $D\{\cdot\}$ may represent a vector diagonalization operation:

$$H(t_2) = H(t_1) \cdot D\left\{\frac{\overline{h_1}(t_2)}{\overline{h_1}(t_1)}\right\} \quad (9)$$

$$H = \begin{bmatrix} h_{1,1} & \cdots & h_{1,2N} \\ \vdots & \ddots & \vdots \\ h_{M,1} & \cdots & h_{M,2N} \end{bmatrix}$$

Taking the antenna configuration shown in FIG. 7 as an example, a full-port mapping-based CSI process in a long periodicity may involve antenna port subsets #1-#4. The CSI feedback can be implemented with a corresponding codebook or other CSI indicators based on the overall channel information. A full-port mapping-based CSI process in a short periodicity may only involve an antenna port subset #1 (or any other antenna port subset). The CSI feedback can be implemented with a corresponding codebook or other CSI indicators based on partial channel information.

[0048] In some embodiments, in case that the UE transmits the CSI based on independent partial channel information, the PMI feedback should be applied to each of CSI processes with a corresponding codebook supporting the number of respective antenna ports. In this case, $H(t_1)$ and $H(t_2)$ may be represented as the following equations (10) and (11) respectively:

$$H(t_1) = W_1(t_1)W_2(t_2) \quad (10)$$

$$H(t_2) = W_1(t_1)\delta\{W_2(t_1), W'(t_2)\} \quad (11)$$

where the function $\delta\{\cdot\}$ may represent a codeword adjusting method according to W' , which may represent the feedback of the partial channel information in a short period. The W_1W_2 structure may represent an existing dual PMI feedback codebook structure.

5 Furthermore, if a single PMI is configured, then:

$$H(t_1) = W(t_1) \quad (12)$$

$$H(t_2) = \delta\{W(t_1), W'(t_2)\} \quad (13)$$

[0049] Still taking the antenna configuration shown in FIG. 7 as an example, a full-port mapping-based CSI process in a long periodicity may involve the antenna port subsets #1-#4. The CSI feedback can be implemented with a corresponding codebook or other CSI indicators based on the overall channel information. A full-port mapping-based CSI process in a short periodicity may only involve a pair of bi-polarized antenna ports (with a same location, in different polarizations). The short-period CSI feedback should be performed based on the channel information with corresponding codebook or other CSI indicators which can reflect the channel variation between antenna polarizations. Then, the base station may adjust the W or W_2 based on the feedback W' .

[0050] In the above embodiments, additionally or alternatively, the CSI process based on full port mapping can be triggered by the base station irregularly. The CSI-RS measurement based on partial port mapping can be a periodic CSI process in a short periodicity, or can be triggered by the base station irregularly. Such configuration can be configured via high-level signaling semi-statically, or carried by the trigger (for example, the base station).

[0051] It is to be understood that in all of the embodiments described above with reference to FIGs. 1-10, in order to implement operations at the base station and the UE during a single CSI process, a new pattern for the CSI feedback can also be defined. It can be seen from the embodiments as described above, the solution of the present disclosure enables estimation of the channel information based on a partial port mapping method, thereby reducing the overhead for CSI-RS transmission efficiently.

[0052] FIG. 11 is a block diagram of an apparatus 1100 of determining channel information for a channel according to embodiments of the present disclosure. As shown in FIG. 11, the apparatus 1100 may include a reference signal receiving module 1110 which is configured to

receive a CSI-RS from the base station 110, the CSI-RS being transmitted by the base station 110 with a CSI-RS resource mapped to a part of the transmitting antenna ports in the antenna array 200. The apparatus 1100 may further include a partial channel information determining module 1120 which is configured to determine, by measuring the CSI-RS, partial
5 channel information for the channel corresponding to the part of transmitting antenna ports. In addition, the apparatus 1100 may further include an overall channel information determining module 1130 configured to determine overall channel information for the channel based on the partial channel information.

[0053] For the sake of clarity, some optional modules of the apparatus 1100 are not shown in
10 FIG. 11. However, it is to be understood that various features as described with reference to FIGs. 1-10 are likewise applicable to the apparatus 1100. Besides, respective modules of the apparatus 1100 may be hardware modules or software modules. For example, in some embodiments, the apparatus 1100 may be partially or completely implemented by software and/or firmware, e.g., implemented as a computer program product embodied on a computer
15 readable medium. Alternatively or additionally, the apparatus 1100 may be partially or completely implemented based on hardware, for example, implemented as an integrated circuit (IC) chip or an application specific integrated circuit (ASIC), a system on chip (SOC), a field programmable gate array (FPGA) and so on. The scope of the present disclosure is not limited in this aspect.

[0054] Specifically, the modules shown in FIG. 11 can be partially or completely
20 implemented as hardware modules, software modules, firmware modules or any combination thereof. In particular, in some embodiments, the procedure, method or process described in the preceding description can be implemented by a UE or hardware in a base station. For example, the UE can implement the method 300 with its transmitter, receiver, transceiver
25 and/or processor or controller.

[0055] The present disclosure may be a system, an apparatus, a device, a method, and/or a computer program product. The computer program product may include a computer readable storage medium (or media) having computer readable program instructions thereon for causing a processor to carry out aspects of the present disclosure.

[0056] The computer readable storage medium can be a tangible device that can retain and
30 store instructions for use by an instruction execution device. The computer readable storage medium may be, for example, but is not limited to, an electronic storage device, a magnetic

storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing. A non-exhaustive list of more specific examples of the computer readable storage medium includes the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM),
5 an erasable programmable read-only memory (EPROM or Flash memory), a static random access memory (SRAM), a portable compact disc read-only memory (CD-ROM), a digital versatile disk (DVD), a memory stick, a floppy disk, a mechanically encoded device such as punch-cards or raised structures in a groove having instructions recorded thereon, and any suitable combination of the foregoing. A computer readable storage medium, as used herein,
10 is not to be construed as being transitory signals per se, such as radio waves or other freely propagating electromagnetic waves, electromagnetic waves propagating through a waveguide or other transmission media (e.g., light pulses passing through a fiber-optic cable), or electrical signals transmitted through a wire.

[0057] Computer readable program instructions described herein can be downloaded to
15 respective computing/processing devices from a computer readable storage medium or to an external computer or external storage device via a network, for example, the Internet, a local area network, a wide area network and/or a wireless network. The network may comprise copper transmission cables, optical transmission fibers, wireless transmission, routers, firewalls, switches, gateway computers and/or edge servers. A network adapter card or
20 network interface in each computing/processing device receives computer readable program instructions from the network and forwards the computer readable program instructions for storage in a computer readable storage medium within the respective computing/processing device.

[0058] Computer readable program instructions for carrying out operations of the present
25 disclosure may be assembler instructions, instruction-set-architecture (ISA) instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, or either source code or object code written in any combination of one or more programming languages, including an object oriented programming language such as Smalltalk, C++ or the like, and conventional procedural programming languages, such as the
30 “C” programming language or similar programming languages. The computer readable program instructions may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the

remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider). In some embodiments, electronic circuitry including, for example, programmable logic circuitry, field-programmable gate arrays (FPGA), or programmable logic arrays (PLA) may execute the computer readable program instructions by utilizing state information of the computer readable program instructions to personalize the electronic circuitry, in order to perform aspects of the present disclosure.

[0059] Aspects of the present disclosure are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems), and computer program products according to embodiments of the present disclosure. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer readable program instructions.

[0060] These computer readable program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. These computer readable program instructions may also be stored in a computer readable storage medium that can direct a computer, a programmable data processing apparatus, and/or other devices to function in a particular manner, such that the computer readable storage medium having instructions stored therein comprises an article of manufacture including instructions which implement aspects of the function/act specified in the flowchart and/or block diagram block or blocks.

[0061] The computer readable program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other device to cause a series of operational steps to be performed on the computer, other programmable apparatus or other device to produce a computer implemented process, such that the instructions which execute on the computer, other programmable apparatus, or other device implement the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0062] The flowchart and block diagrams illustrate the architecture, functionality, and

operation of possible implementations of systems, methods and computer program products according to various embodiments of the present disclosure. In this regard, each block in the flowchart or block diagrams may represent a module, snippet, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions.

[0063] The descriptions of the various embodiments of the present disclosure have been presented for purposes of illustration, but are not intended to be exhaustive or limited to the embodiments disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the described embodiments. The terminology used herein was chosen to best explain the principles of the embodiments, the practical application or technical improvement over technologies found in the marketplace, or to enable others of ordinary skill in the art to understand the embodiments disclosed herein.

I/We Claim:

1. A method of determining channel information for a channel, comprising:
receiving a channel state information-reference signal (CSI-RS) from a base station,
the CSI-RS being transmitted by the base station with a CSI-RS resource mapped to a part of
5 transmitting antenna ports in an antenna array;
determining, by measuring the CSI-RS, partial channel information for the channel
corresponding to the part of transmitting antenna ports; and
determining overall channel information for the channel based on the partial channel
information.

2. The method of Claim 1, wherein the CSI-RS is transmitted by the base station with
a first CSI-RS resource mapped to a column of transmitting antenna ports in the antenna array
and a second CSI-RS resource mapped to a row of transmitting antenna ports in the antenna
array, and the determining partial channel information comprises:

15 determining first partial channel information corresponding to the column of
transmitting antenna ports; and
determining second partial channel information corresponding to the row of
transmitting antenna ports.

3. The method of Claim 2, wherein determining the overall channel information
comprises:

determining the overall channel information by calculating a product of the first and
second partial channel information.

4. The method of Claim 1, wherein the CSI-RS is transmitted by the base station with
a third CSI-RS resource mapped to a row of transmitting antenna ports in the antenna array, a
fourth CSI-RS resource mapped to a first group of a column of transmitting antenna ports in
one of two polarizations, and a fifth CSI-RS resource mapped to a second group of the
column of transmitting antenna ports in the other of the two polarizations, and the
30 determining partial channel information comprises:

determining third partial channel information corresponding to the row of transmitting
antenna ports;

determining fourth partial channel information corresponding to the first group of the

column of transmitting antenna ports; and

determining fifth partial channel information corresponding to the second group of the column of transmitting antenna ports.

5 5. The method of Claim 4, wherein determining the overall channel information comprises:

determining, based on the third, fourth, and fifth partial channel information, the overall channel information by calculating a product.

10 6. The method of Claim 1, wherein the CSI-RS is transmitted by the base station with a sixth CSI-RS resource mapped to a third group of transmitting antenna ports and a seventh CSI-RS resource mapped to a fourth group of transmitting antenna ports, the third group of transmitting antenna ports being distributed in a first antenna block of the antenna array and the fourth group of transmitting antenna ports being distributed in a second antenna block of
15 the antenna array, the first antenna block being larger than the second antenna block, and the determining partial channel information comprises:

determining sixth partial channel information corresponding to the third group of transmitting antenna ports; and

20 determining seventh partial channel information corresponding to the fourth group of transmitting antenna ports.

7. The method of Claim 6, wherein determining the overall channel information comprises:

25 determining the overall channel information by calculating a product of the sixth and seventh partial channel information.

8. The method of Claim 1, wherein the CSI-RS is transmitted by the base station with a plurality of groups of CSI-RS resources mapped to a plurality of groups of transmitting antenna ports respectively, and the determining partial channel information comprises:

30 determining a plurality of parts of channel information corresponding to the plurality of groups of transmitting antenna ports respectively.

9. The method of Claim 8, wherein determining the overall channel information comprises:

determining the overall channel information by applying a linear combination to the plurality of parts of channel information.

10. The method of Claim 1, further comprising:

5 determining at least one of:

first channel state information corresponding to the partial channel information;

and

second channel state information corresponding to the overall channel information.

10 11. The method of Claim 10, further comprising:

transmitting at least one of the first and second channel state information to the base station.

15 12. The method of Claim 11, further comprising:

transmitting the first channel state information in a first periodicity; and

transmitting the second channel state information in a second periodicity, the second periodicity being longer than the first periodicity.

20 13. An apparatus for determining channel information for a channel, comprising:

a reference signal receiving module configured to receive a channel state information-reference signal (CSI-RS) from a base station, the CSI-RS being transmitted by the base station with a CSI-RS resource mapped to a part of transmitting antenna ports in an antenna array;

25 a partial channel information determining module configured to determine, by measuring the CSI-RS, partial channel information for the channel corresponding to the part of transmitting antenna ports; and

an overall channel information determining module configured to determine overall channel information for the channel based on the partial channel information.

30 14. The apparatus of Claim 13, wherein the CSI-RS is transmitted by the base station with a first CSI-RS resource mapped to a column of transmitting antenna ports in the antenna array and a second CSI-RS resource mapped to a row of transmitting antenna ports in the antenna array, and the partial channel information determining module is configured to:

determine first partial channel information corresponding to the column of transmitting antenna ports; and

determine second partial channel information corresponding to the row of transmitting antenna ports.

5

15. The apparatus of Claim 14, wherein the overall channel information determining module is configured to:

determine the overall channel information by calculating a product of the first and second partial channel information.

10

16. The apparatus of Claim 13, wherein the CSI-RS is transmitted by the base station with a third CSI-RS resource mapped to a row of transmitting antenna ports in the antenna array, a fourth CSI-RS resource mapped to a first group of a column of transmitting antenna ports in one of two polarizations, and a fifth CSI-RS resource mapped to a second group of the column of transmitting antenna ports in the other of the two polarizations, and the partial channel information determining module is configured to:

15

determine third partial channel information corresponding to the row of transmitting antenna ports;

20

determine fourth partial channel information corresponding to the first group of the column of transmitting antenna ports; and

determine fifth partial channel information corresponding to the second group of the column of transmitting antenna ports.

25

17. The apparatus of Claim 16, wherein the overall channel information determining module is configured to:

determine, based on the third, fourth, and fifth partial channel information, the overall channel information by calculating a product.

30

18. The apparatus of Claim 13, wherein the CSI-RS is transmitted by the base station with a sixth CSI-RS resource mapped to a third group of transmitting antenna ports and a seventh CSI-RS resource mapped to a fourth group of transmitting antenna ports, the third group of transmitting antenna ports being distributed in a first antenna block of the antenna array and the fourth group of transmitting antenna ports being distributed in a second antenna block of the antenna array, the first antenna block being larger than the second antenna block,

and the partial channel information determining module is configured to:

determine sixth partial channel information corresponding to the third group of transmitting antenna ports; and

5 determine seventh partial channel information corresponding to the fourth group of transmitting antenna ports.

19. The apparatus of Claim 18, wherein the overall channel information determining module is configured to:

10 determine the overall channel information by calculating a product of the sixth and seventh partial channel information.

20. The apparatus of Claim 13, wherein the CSI-RS is transmitted by the base station with a plurality of groups of CSI-RS resources mapped to a plurality of groups of transmitting antenna ports respectively, and the partial channel information determining module is
15 configured to:

determine a plurality of parts of channel information corresponding to the plurality of groups of transmitting antenna ports respectively.

21. The apparatus of Claim 20, wherein the overall channel information determining
20 module is configured to:

determine the overall channel information by applying a linear combination to the plurality of parts of channel information.

22. The apparatus of Claim 13, further comprising:
25 a channel state information determining module configured to determine at least one of:

first channel state information corresponding to the partial channel information;
and

30 second channel state information corresponding to the overall channel information.

23. The apparatus of Claim 22, further comprising:

a channel state information transmitting module configured to transmit at least one of the first and second channel state information to the base station.

24. The apparatus of Claim 23, wherein the channel state information transmitting module is configured to:

transmit the first channel state information in a first periodicity; and

5 transmit the second channel state information in a second periodicity, the second periodicity being longer than the first periodicity.

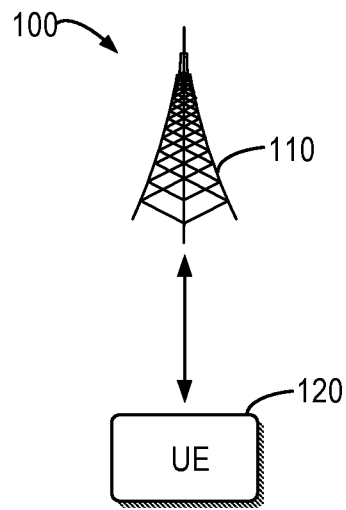


FIG. 1

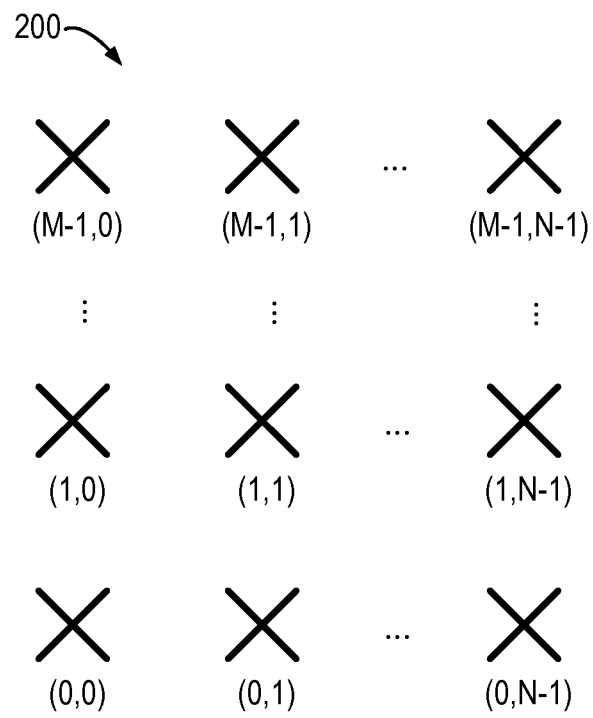


FIG. 2

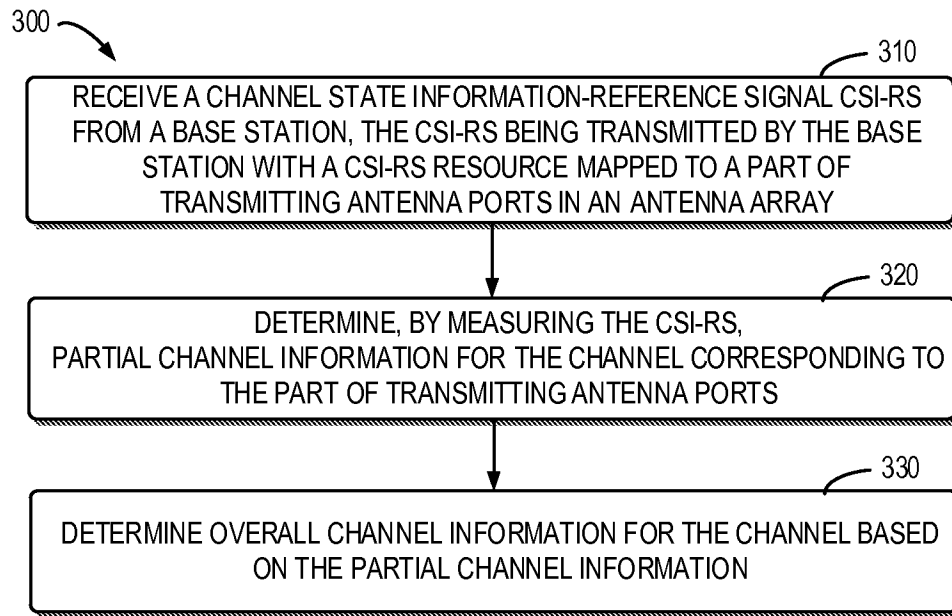


FIG. 3

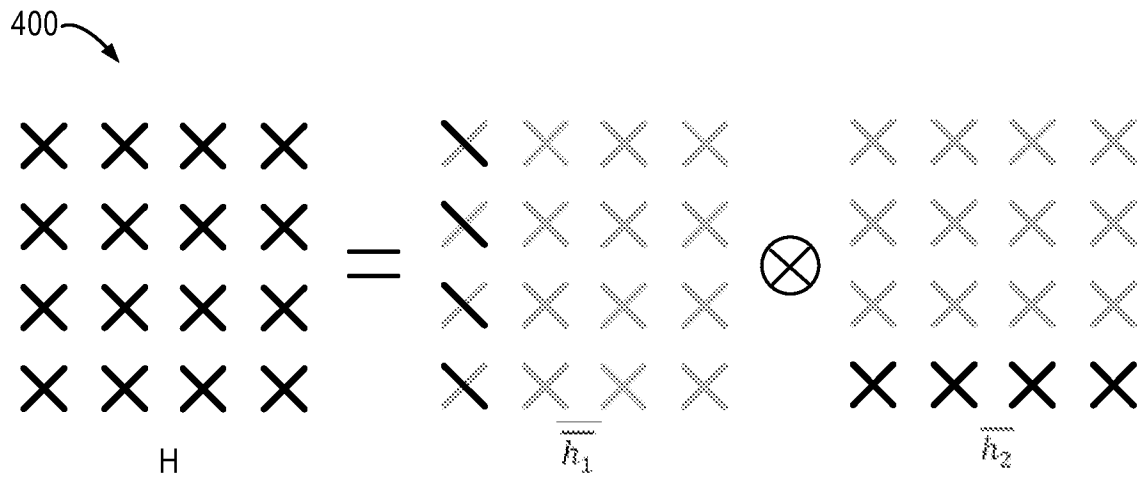


FIG. 4

500

$$\begin{array}{ccccccc}
 \begin{array}{c} \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \end{array} & = & \begin{array}{c} \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \end{array} & \otimes & \begin{array}{c} \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \end{array} & + & \begin{array}{c} \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \end{array} & \otimes & \begin{array}{c} \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \end{array} \\
 \text{H} & & \overline{\overline{h_4}} & & \overline{\overline{h_2}} & & \overline{\overline{h_5}} & & \overline{\overline{h_3}}
 \end{array}$$

FIG. 5

600

$$\begin{array}{ccc}
 \begin{array}{c} \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \end{array} & = & \begin{array}{c} \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \end{array} \otimes \begin{array}{c} \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \end{array} \\
 \text{H} & & \overline{\overline{h_6}} \quad \overline{\overline{h_7}}
 \end{array}$$

FIG. 6

700

$$\begin{array}{ccccccc}
 \begin{array}{c} \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \end{array} & = & \begin{array}{c} \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \end{array} & + & \begin{array}{c} \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \end{array} & + & \begin{array}{c} \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \end{array} & + & \begin{array}{c} \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \\ \times \times \times \times \end{array} \\
 & & \text{SUBSET \#1} & & \text{SUBSET \#2} & & \text{SUBSET \#3} & & \text{SUBSET \#4}
 \end{array}$$

FIG. 7

800 

FIG. 8

900 

FIG. 9

1000 

The diagram shows a 4x4 grid of black crosses on the left, followed by an equals sign. To the right of the equals sign are four 4x4 grids of crosses, separated by plus signs. The first grid has black crosses at (1,1), (1,3), (3,1), and (3,3), with all other crosses being gray. The second grid has black crosses at (1,2), (2,1), (3,4), and (4,3), with all other crosses being gray. The third grid has black crosses at (1,4), (2,3), (3,2), and (4,1), with all other crosses being gray. The fourth grid has black crosses at (2,2), (2,4), (4,2), and (4,4), with all other crosses being gray.

FIG. 10

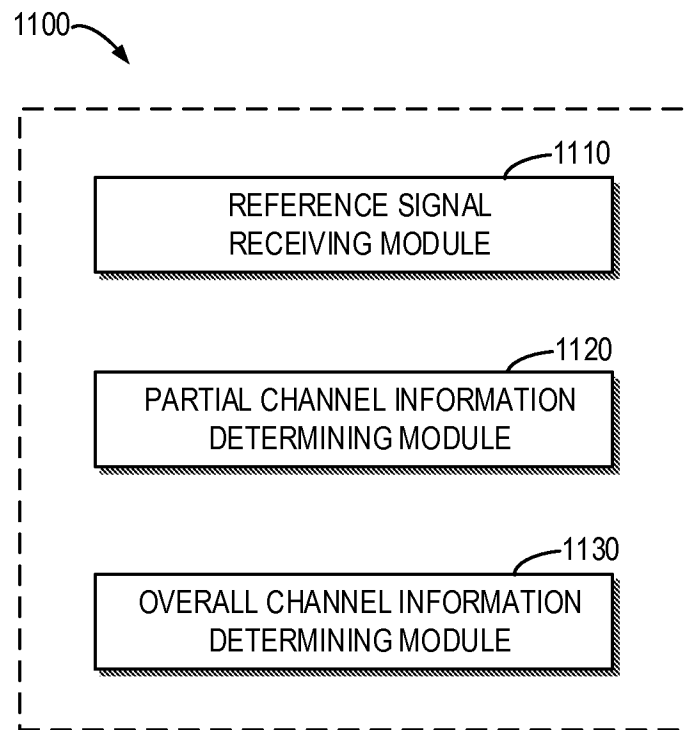


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/000462

A. CLASSIFICATION OF SUBJECT MATTER INV. H04B7/0456 H04B7/06 H04L5/00 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) H04B H04L		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2016/039604 A1 (SAMSUNG ELECTRONICS CO LTD [KR]) 17 March 2016 (2016-03-17) paragraphs [0094], [0119] - [0128], [0150], [0174], [0180], [0181], [0217], [0254], [0280] - paragraphs [0287], [0303], [0305], [0331], [0338], [0344] - [0345], [0382]; figures 1, 6a, 8a, 11a, 11b, 18a, 18b, 22, 23b, 24 ----- -/--	1,6-11, 13,18-23 12,24
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents :		
"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 6 June 2017	Date of mailing of the international search report 13/06/2017	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Panahandeh, Ali	

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2017/000462

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ALCATEL-LUCENT SHANGHAI BELL ET AL: "Considerations on CSI feedback enhancements for high-priority antenna configurations", 3GPP DRAFT; R1-112420 CONSIDERATIONS ON CSI FEEDBACK ENHANCEMENTS FOR HIGH-PRIORITY ANTENNA CONFIGURATIONS CLEAN, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. Athens, Greece; 20110822, 18 August 2011 (2011-08-18), XP050537814, [retrieved on 2011-08-18]	1-3,8, 10-15, 20,22-24
Y	Section 3.1 paragraph 1 Section 5.1 paragraph 1 Section 5.2 paragraph 1; page 5 page 5, paragraph 1 figures 1,2	5,12,17, 24
X	----- WO 2015/190847 A1 (BEIJING SAMSUNG COMMUNICATION TECHNOLOGY) 17 December 2015 (2015-12-17)	1,2,4,6, 8,10,11, 13,14, 16,18, 20,22,23 5,17
Y	paragraphs [0102] - [0104], [0107] - paragraphs [0111], [0118], [0159], [0160]; figures 7,8,11,12,13, 16 -----	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2017/000462

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2016039604 A1	17-03-2016	US 2016080052 A1 WO 2016039604 A1	17-03-2016 17-03-2016
WO 2015190847 A1	17-12-2015	CN 105471552 A EP 3155855 A1 KR 20170018046 A US 2017134130 A1 WO 2015190847 A1	06-04-2016 19-04-2017 15-02-2017 11-05-2017 17-12-2015