PTO-1390 (12-12)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371

Attorney Docket No.	
P5158US00	
U.S. Application No. (if known, see 37 CFR 1.5)	

International Application No.	International Filing Date	Priority Date Claimed
PCT/KR2011/004835	July 1, 2011	July 5, 2010

Title of Invention
TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

First Named Inventor
Kyoungmin PARK

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). NOTE: The express request under 35 U.S.C. 371(f) will not be effective unless the requirements under 35 U.S.C. 371(c)(1), (2), and (4) for payment of the basic national fee, copy of the International Application and English translation thereof (if required), and the oath or declaration of the inventor(s) have been received.
2. ☒ A copy of the International Application (35 U.S.C. 371(c)(2)) is attached hereto (not required if the International Application was previously communicated by the International Bureau or was filed in the United States Receiving Office (RO/US)).
3. An English language translation of the International Application (35 U.S.C. 371(c)(2))
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
4. An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4))
   a. ☒ is attached.
   b. ☐ was previously filed in the international phase under PCT Rule 4.17(iv).

Items 5 to 8 below concern amendments made in the international phase.

PCT Article 19 and 34 amendments

5. ☐ Amendments to the claims under PCT Article 19 are attached (not required if communicated by the International Bureau) (35 U.S.C. 371(c)(3)).
6. ☐ English translation of the PCT Article 19 amendment is attached (35 U.S.C. 371(c)(3)).
7. ☐ English translation of annexes (Article 19 and/or 34 amendments only) of the International Preliminary Examination Report is attached (35 U.S.C. 371(c)(5)).

Cancellation of amendments made in the international phase

8a. ☐ Do not enter the amendment made in the international phase under PCT Article 19.

8b. ☐ Do not enter the amendment made in the international phase under PCT Article 34.

NOTE: A proper amendment made in English under Article 19 or 34 will be entered in the U.S. national phase application absent a clear instruction from applicant not to enter the amendment(s).

The following items 9 to 17 concern a document(s) or information included.

9. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
10. ☒ A preliminary amendment.
11. ☒ An Application Data Sheet under 37 CFR 1.76.
12. ☒ A substitute specification. NOTE: A substitute specification cannot include claims. See 37 CFR 1.125(b).
13. ☒ A power of attorney and/or change of address letter.
14. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.3 and 37 CFR 1.821-1.825.
15. ☐ Assignment papers *(cover sheet and document(s))*. Name of Assignee: _____
16. ☒ 37 CFR 3.73 Statement *(when there is an Assignee)*.

This collection of information is required by 37 CFR 1.414 and 1.491-1.492. The information is required to obtain or retain a benefit by the public, which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 15 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

U.S. APPLN. No. (if known – see 37 CFR 1.5)	INTERNATIONAL APPLICATION No.	ATTORNEY DOCKET No.
	PCT/KR2011/004835	P5158US00

17. ■ Other items or information:

Int. App. Status Report; WO 2012/005476 A3; WO 2012/005476 A2; PCT Request; PCT/ISA/202; PCT/RO/105; PCT/IB/301; PCT/IB/304; PCT/IB/308(First Notice); PCT/IB/308 (Second and Supplementary Notice); PCT/IB/311; PCT/ISA/237; PCT/ISA/210; PCT/ISA/220

The following fees have been submitted.	CALCULATIONS	PTO USE ONLY
18. ■ Basic national fee (37 CFR 1.492(a)) **$390**	$ 390.00	
19. ■ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** All other situations **$250**	$ 250.00	
20. ■ Search fee (37 CFR 1.492(b)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority .....**$120** International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB .....**$500** All other situations **$630**	$ 500.00	
TOTAL OF 18, 19, and 20 =	$ 1,140.00	
■ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)). Fee for each additional 50 sheets of paper or fraction thereof **$320**		

Total Sheets	Extra Sheets	Number of each addition 50 or fraction thereof (round **up** to a whole number)	RATE	
159 - 100 =	59 / 50 =	2	x **$320**	$ 640.00

Surcharge of **$130.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	31 - 20 =	11	x **$62**	$ 682.00	
Independent claims	4 - 3 =	1	x **$250**	$ 250.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$460**	$	
			TOTAL OF ABOVE CALCULATIONS =	$ 1,572.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. Fees above are reduced by ½.					
			SUBTOTAL =	$ 2,712.00	
Processing fee of **$130.00** for furnishing the English translation later than 30 months form the earliest claimed priority date (37 CFR 1.492(i)). +				$	
			TOTAL NATIONAL FEE =	$ 2,712.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property. +				$	
			TOTAL FEES ENCLOSED =	$ 2,712.00	
			Amount to be refunded:	$	
			Amount to be charged:	$	

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a. ☐ A check in the amount of $_____ to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $_____ to cover the above fees.

c. ☒ The Director is hereby authorized to charge additional fees which may be required, or credit any overpayment, to Deposit Account No. 50-3698 as follows:

i. ☒ any required fee.

ii. ☐ any required fee except for excess claims fees required under 37 CFR 1.492(d) and (e) and multiple dependent claim fee required under 37 CFR 1.492(f).

d. ☒ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038. The PTO-2038 should only be mailed or faxed to the USPTO. However, when paying the basic national fee, the PTO-2038 may NOT be faxed to the USPTO.

ADVISORY: If filing by EFS-Web, do **NOT** attach the PTO-2038 form as a PDF along with your EFS-Web submission. Please be advised that this is **not** recommended and by doing so your **credit card information may be displayed via PAIR**. To protect your information, it is recommended to pay fees online by using the electronic payment method.

NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

Correspondence Address

☒ The address associated with Customer Number: 58027 **OR** ☐ Correspondence address below

Name					
Address					
City		State		Zip Code	
Country		Telephone			
Email					

Signature	/hae-chan park/	Date	2012-12-28
Name (Print/Type)	Hae-Chan Park	Registration No. (Attorney/Agent)	50114

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	P5158US00
	Application Number	
Title of Invention	TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Kyoungmin		PARK	

Residence Information (Select One) ○ US Residency ◉ Non US Residency ○ Active US Military Service

City	Seoul	Country of Residence i	KR

Mailing Address of Inventor:

Address 1	Pantech Bldg., I-2, DMC, Sangam-dong, Mapo-gu		
Address 2			
City	Seoul	**State/Province**	
Postal Code	121-270	**Country** i	KR

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	58027		
Email Address		Add Email	Remove Email

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	Application Number	
Title of Invention	TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH	

Application Information:

Title of the Invention	TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH		
Attorney Docket Number	P5158US00	**Small Entity Status Claimed** ☐	
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		**Sub Class (if any)**	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	10	**Suggested Figure for Publication (if any)**	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	58027		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	a 371 of international	PCT/KR2011/004835	2011-07-01

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Foreign Priority Information:

PTO/AIA/14 (08-12)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	P5158US00
	Application Number	
Title of Invention	TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH	

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Priority Claimed
10-2010-0064573	KR	2010-07-05	◉ Yes ○ No

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Authorization to Permit Access:

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	P5158US00
	Application Number	
Title of Invention	TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH	

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. ☒

Organization Name	Pantech Co., Ltd.

Mailing Address Information:

Address 1	Pantech Bldg., I-2, DMC, Sangam-dong, Mapo-gu		
Address 2			
City	Seoul	**State/Province**	
Country	KR	Postal Code	121-270
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button.

Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section only if non-applicant assignee information is desired to be included on the patent application publication in accordance with 37 CFR 1.215(b). Do not include in this section an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest), as the patent application publication will include the name of the applicant(s).

If the Assignee is an Organization check here. ☐

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	P5158US00
	Application Number	
Title of Invention	TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH	

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information:			
Address 1			
Address 2			
City		**State/Province**	
Country [i]		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee Data may be generated within this form by selecting the Add button.

Signature:

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications

Signature	/hae-chan park/			Date (YYYY-MM-DD)	2012-12-28
First Name	Hae-Chan	Last Name	Park	Registration Number	50114

Additional Signature may be generated within this form by selecting the Add button.

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Description

Title of Invention: TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

Technical Field

[1] The present invention relates to a wireless communication system, and more particularly, to a wireless communication system that uses multiple input multiple output (MIMO) in both a transmitting end and a receiving end.

Background Art

[2] As communication systems have developed, various wireless terminals have been utilized by consumers, such as companies and individuals.

[3] A current mobile communication system, such as 3GPP, LTE (Long Term Evolution), LTE-A (LTE Advanced), and the like, may be a high capacity communication system capable of transmitting and receiving various data such as image data, wireless data, and the like, beyond providing a sound-based service. Accordingly, there is a desire for a technology that transmits high capacity data, which is comparable with a wired communication network. Also, the system is required to minimize loss of information and increase transmission efficiency of the system so as to enhance performance of the system.

Detailed Description of the Invention

Technical Solution

[4] In accordance with an aspect of the present invention, there is provided a communication method of a transmitting device including a first precoder and a second precoder, the method including: determining first information to restrict a precoding matrix from being used as a first precoding matrix of the first

precoder, and second information to restrict a precoding matrix from being used as a second precoding matrix of the second precoder in a corresponding codebook with respect to each layer; and transmitting, to a receiving device, codebook restricting information including at least one of the determined first information and second information.

[5] In accordance with another aspect of the present invention, there is provided a transmitting device, the device including: a layer mapper to map a codeword to a layer; a precoder including a first precoder and a second precoder that performs precoding on a data symbol corresponding to the codeword mapped to the layer by the layer mapper, using a first precoding matrix and a second precoding matrix selected from a corresponding codebook; and an antenna array to transmit signals output from the precoder, and the codeword includes at least one of first information to restrict a precoding matrix from being used as the first precoding matrix and second information to restrict a precoding matrix from being used as the second precoding matrix in the corresponding codebook with respect to each layer.

[6] In accordance with another aspect of the present invention, there is provided a communication method of a receiving device in a wireless communication system, the method including: receiving codebook restricting information including at least one of first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix for each layer; and transmitting, to a transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix being selected, based on the codebook restricting information, from among precoding matrices that are not restricted from being used as the first precoding matrix or the

second precoding matrix in a codebook.

[7] In accordance with another aspect of the present invention, there is provided a receiving device in a wireless communication system, the device including: an antenna array to receive, as codebook restricting information, at least one of first information to restrict a precoding matrix from being used as a first precoding matrix and first information to restrict a precoding matrix from being used as a second precoding matrix with respect to each layer; and a channel information feedback device to transmit, to a transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix being selected, based on the codebook restricting information, from among precoding matrices that are not restricted from being used as the first precoding matrix of the second precoding matrix in a codebook.

Brief Description of the Drawings

[8] FIG. 1 is a block diagram illustrating a wireless communication system according to embodiments of the present invention;

[9] FIG. 2 is a diagram illustrating a wireless communication system in which a base station and a user equipment exchange codebook restricting information and channel status information in a case of codebook restriction;

[10] FIG. 3 is a flowchart further illustrating a reference signal and signal transmission in the wireless communication system that exchanges codebook restricting information and channel status information of FIG. 2;

[11] FIG. 4 is a block diagram illustrating a base station and a user equipment in a MIMO wireless communication system according to an embodiment of the present invention;

[12] FIG. 5 is a diagram illustrating a channel between a base station and a user equipment that use a polarized antenna array of FIG. 4;

[13] FIG. 6 is a flowchart illustrating a communication method of a transmitting device according to another embodiment of the present invention; and

[14] FIG. 7 is a flowchart illustrating a communication method of a receiving device according to another embodiment of the present invention.

Mode for Carrying Out the Invention

[15] Hereinafter, exemplary embodiments of the present invention will be described with reference to the accompanying drawings. In the following description, the same elements will be designated by the same reference numerals although they are shown in different drawings. Further, in the following description of the present invention, a detailed description of known functions and configurations incorporated herein will be omitted when it may make the subject matter of the present invention rather unclear.

[16] FIG. 1 is a block diagram illustrating a wireless communication system according to embodiments of the present invention.

[17] The wireless communication system may be widely installed so as to provide various communication services such as voice data, packet data, and the like.

[18] Referring to FIG. 1, the wireless communication system may include a user equipment (UE) 10 and a base station (BS) 20.

[19] The user equipment 10 may be an inclusive concept indicating a user terminal utilized in a wireless communication, including a UE (User Equipment) in WCDMA, LTE, HSPA, and the like, and an MS (Mobile Station), a UT (User Terminal), an SS (Subscriber Station), a wireless device and the like in GSM.

[20] The base station 20 or a cell may generally refer to a station where communication with the user equipment 10 is performed, and may also be referred to as a Node-B, an eNB (evolved Node-B), a BTS (Base Transceiver System), an access point, a relay node, and the like.

[21] In the specifications, the user equipment 10 and the base station 20 are used as two inclusive transceiving subjects to embody the technology and technical concepts described in the specifications, and may not be limited to a predetermined term or word.

[22] An embodiment of the present invention may be applicable to an asynchronous wireless communication scheme that is advanced through GSM, WCDMA, and HSPA, to be LTE (Long Term Evolution) and LTE-advanced, and may be applicable to a synchronous wireless communication scheme that is advanced through CDMA and CDMA-2000, to be UMB. Embodiments of the present invention may not be limited to a specific wireless communication scheme, and may be applicable to all technical fields to which a technical idea of the present invention is applicable.

[23] The wireless communication system according to embodiments of the present invention may support an uplink and/or downlink HARQ (Hybrid Automatic Repeat request), and may use a CQI (channel quality indicator) for link adaptation. Also, a multiple access scheme for downlink transmission and a multiple access scheme for uplink transmission may be different from each other. For example, a downlink may use OFMDA (Orthogonal Frequency Division Multiple Access) and an uplink may use SC-FDMA (Single Carrier-Frequency Division Multiple Access).

[24] To support high-speed information transmission for the user, the wireless communication system may consider using a Multiple Input Multiple Output (MIMO) scheme that transfers information through the same band using an antenna array including a multi-antenna.

[25] To embody an effective MIMO system, a MIMO wireless communication system may need to provide, to a transmitting device, information associated with a propagation channel or information associated with a precoder or a precoding matrix (hereinafter referred to as a precoding matrix) appropriate for a propagation channel, to increase transmission capacity. In this example, the former requires a large amount of feedback overhead, whereas the latter requires a relatively small amount of feedback overhead.

[26] In the latter case, each of the user equipment 10 and the base station 20 stores a codebook that defines N available precoding matrices, and expresses an index or an indicator indicating or indexing (corresponding to) each precoding matrix, and identification. Each user equipment 10 selects a precoding matrix appropriate for a propagation channel, and transmits an index indexing the selected precoding matrix to the base station 20. The base station 20 receives precoding matrix indices from each user equipment 10, and selects a MIMO mode or a user equipment or performs precoding based on the received precoding matrix indices.

[27] In this example, as a size of a codebook becomes larger since a number of available precoding matrices is large, the precoding performance of the base station 120 increases. However, an amount of feedback overhead of the user equipment 10 required for reporting the precoding matrices or corresponding indices to the base station 20 may be increased. Therefore, when a large size codebook is used, a codebook restriction or a codebook subset restriction that restricts at least one precoding matrix in a codebook may need to be used for more effective precoding.

[28] The codebook restriction is a scheme that generates a codebook including various precoding matrices, selects a precoding matrix to be used/not used in the codebook for each

cell or each user equipment, and uses different codebooks for each cell or each user equipment based on codebook restricting information (hereinafter referred to as "codebook restricting information") associated with a precoding matrix to be not used. When the codebook restriction scheme is used, the whole wireless communication system has a large size codebook, but a codebook that is used by each cell or each user equipment is configured of subsets of the codebook, and has a small size, and is configured of only precoding matrices appropriate for a given environment and thus, a precoding gain may be increased.

[29] For example, when downlink MIMO transmission between the base station 20 and the user equipment 10 simultaneously performs transmission with respect to up to 4 layers, the user equipment 10 may transfer, to the base station 20 using a rank indicator (RI), a number of layers that the user equipment 10 is capable of receiving. In this example, 16 precoding matrices may be designated for each rank during the downlink MIMO transmission between the base station 20 and the user equipment 10, and a total of 64 precoding matrices may be configured as shown in Table 1.

[30] [Table 1]

[31]

RI \ PMI	0	1	2	.....	15
1	a0	a1	a2	.....	a15
2	a16	a17	a18	.....	a31
3	a32	a33	a34	.....	a47
4	a48	a49	a50	.....	a63

[32] In a case in which the codebook restriction is used, when whether a precoding matrix is to be used is determined for each of the 64 precoding matrices and codebook restricting information is transmitted based on a bitmap format that designates whether

each precoding matrix is to be used using 1 bit, a total of 64 bits may be required. For example, a corresponding order of an available precoding matrix is expressed to be 1, and a corresponding order of an unavailable precoding matrix is expressed to be 0, as shown in [001010010.....010].

[33] The user equipment 10 may report, to the base station 20 as channel status information, 64 indices corresponding to the total of 64 precoding matrices using a total of 6 bits. In this example, when a codebook restriction that restricts the use of 32 precoding matrices from among the 64 precoding matrices is used, a number of information to be distinguished by 6 bits may be decreased from 64 to 32 and thus, a degree of reliability of a feedback signal may be increased. The user equipment 10 may decrease a number of bits that expresses the indices corresponding to the precoding matrices to 5 bits so as to reduce an amount of feedback overhead of the channel status information.

[34] In addition, the use of precoding matrices that are predicted to cause inter-cell interference may be restricted by the codebook restriction and thus, the inter-cell interference may be prevented in advance. In particular, when a beamforming like precoding that is based on a location of each user equipment is performed, a user equipment located in a cell edge may cause serious inter-cell interference. To prevent the inter-cell interference in advance, a codebook restriction may be performed for each cell and thus, the inter-cell interference may be controlled.

[35] The base station 20 may use a multistage precoder including at least two precoders. The codebook restriction that restricts a precoding matrix to be used for each precoder may also be applicable, when the multistage precoder is used. In this example, a number of precoding matrices is generally increased and a number of bits to be used for codebook restricting information for the codebook restriction may also be increased.

[36] In particular, a high signaling and feedback overhead may be required to support high speed information transmission in an uplink or a downlink and thus, a number of bits that the base station 20 uses to inform each user equipment 10 of the codebook restriction may need to be reduced.

[37] The wireless communication system according to embodiments of the present invention has been described. Hereinafter, with reference to FIGS. 2 and 3, a process will be described in which a base station and a user equipment exchange codebook restricting information and channel status information in a wireless communication system when a multistage precoder is used in a case of codebook restriction.

[38] FIG. 2 illustrates a wireless communication system in which a base station and a user equipment exchange codebook restricting information and channel status information in a case of codebook restriction.

[39] Referring to FIG. 2, a wireless communication system 100 may include the base station 120 and may include at least one user equipment existing in the wireless communication system 100, for example, n user equipments 110, like the wireless communication system of FIG. 1. Although the user equipments 110 may correspond to user equipments that are currently being connected or that attempt additional connection, a single user equipment is illustrated in FIG. 2 for ease of descriptions.

[40] The base station 120 includes a multistage precoder including at least two precoders, that is, first and second precoders. The base station 120 stores a first codebook 122 that expresses N first precoding matrices to be used for the first precoder and first indices indexing the first precoding matrices and a second codebook 124 that expresses M second precoding matrices to be used for the second precoder and second indices indexing the second precoding matrices.

[41] The base station stores a restriction book 126 including

ranks and an index (hereinafter referred to as a restriction index) corresponding to each pair of a first index and a second index with respect to each rank. The base station 120 determines a precoding matrix to be used/not used for each cell or for each user equipment, and may transmit, to the user equipment 110, codebook restricting information 128 associated with the precoding matrix to be not used. In this example, the codebook restricting information 128 includes first information that restricts a precoding matrix from being used as a first precoding matrix and second information that restricts a precoding matrix from being used as a second precoding matrix in the first and second codebooks 122 and 124 with respect to each layer.

[42] FIG. 3 is a flowchart further illustrating a reference signal and signal transmission in the wireless communication system that exchanges codebook restricting information and channel status information of FIG. 2.

[43] Referring to FIG. 3, for transmission and reception of data between the user equipment 110 and the base station 120, the base station 120 at a transmitter side transmits a reference signal 130 as further illustrated in FIG. 3, and the user equipment 110 at a receiver side estimates a channel using the reference signal 130. For example, in a case of downlink transmission, the user equipment 110 may estimate a downlink channel. In particular, in a case of OFDM transmission, the user equipment 110 may estimate a channel of each subcarrier. Conversely, in a case of uplink transmission, the base station 120 may estimate an uplink channel.

[44] For the channel estimation, a predetermined signal or symbol may be inserted into a frequency-domain grid at regular or irregular intervals. In this example, the predetermined signal or symbol may be referred to as a reference signal or a reference symbol, a pilot symbol, and the like. In the specifications, the predetermined signal or symbol is referred to as a reference

signal, but this may not be limited thereto. The reference signal 130 may not be used for only the estimation of the frequency-domain channel, but may be used for estimation of a location required for wireless communication between a user equipment and a base station, transmission and reception of control information, transmission and reception of scheduling information, transmission and reception of feedback information, and the like.

[45] There may be various types of reference signals for downlink or uplink transmission, and new reference signals for various purposes have been defined and discussed. For example, reference signals for the uplink transmission may include a DM-RS (Demodulation RS), an SRS (Sounding RS), and the like. Reference signals for the downlink transmission may include a DM-RS (Demodulation RS), CRS (Cell-specific RS), an MBSFN RS, a UE-specific RS, and the like. Also, a CSI-RS is used as a reference signal that a base station transmits to obtain channel status information (CSI) of a center cell or adjacent cells from the user equipment 110 in a case of downlink transmission. The CSI-RS may be used for reporting a CQI (Channel Quality Indicator)/PMI (Precoder Matrix Indicator)/RI (Rank Indicator), and the like. The CSI-RS may be cell-specific so as to be distinguished for each cell included in a base station that transmits the CSI-RS, and may need to be sufficiently scattered in a frequency and a time for a low overhead.

[46] Referring again to FIG. 2, the user equipment 110 stores a first codebook 112 that expresses N first precoding matrices used for a first precoder and first indices indexing the first precoding matrices and a second codebook 114 that expresses M second precoding matrices used for a second precoder and second indices indexing the second precoding matrices. The first codebook 112 and the second codebook 114 may be identical to the first codebook 122 and the second codebook 124 stored in the base

station 120, respectively.

[47] The user equipment 110 stores a restriction book 116, which will be described with reference to Table 4, including ranks and a plurality of indices (hereinafter referred to as a restriction index) corresponding to each pair of a first index and a second index included in each rank. The restriction book 116 stored in each user equipment 110 may be identical to the restriction book 126 stored in the base station 120.

[48] The user equipment 110 may receive codebook restricting information 128 from the base station 120. The codebook restricting information 128 includes at least one of first information that restricts a precoding matrix from being used as a first precoding matrix and second information that restricts a precoding matrix from being used as a second precoding matrix in first and second codebooks for each layer.

[49] The user equipment 110 determines, based on the first information included in the codebook restricting information 128, a first precoding matrix excluding precoding matrices that are restricted from being used as a first precoding matrix, and reports/feeds back 1st channel status information 132 associated with the determined precoding matrix to the base station 120. Also, each user equipment 110 determines, based on the second information included in the codebook restricting information 128, a second precoding matrix excluding precoding matrices that are restricted from being used as a second precoding matrix, and reports/feeds back 2nd channel status information 134 associated with the determined second precoding matrix to the base station 120.

[50] The base station 120 determines precoding matrices of the first precoder and the second precoder from the first codebook 122 and the second codebook 124 based on the channel status information 132 and 134 reported from each user equipment 110, and performs precoding of data symbols using the precoding

matrices.

[51] Referring again to FIG. 3, the base station 120 transmits a precoded signal 136 to the user equipment 110 as illustrated in FIG. 3. Conversely, the user equipment 110 receives the signal 136 and decodes the signal into original data.

[52] The process has been described in which a base station and a user equipment exchange codebook restricting information and channel status information in the wireless communication system when a multistage precoder is used in a case of codebook restriction. Hereinafter, a MIMO wireless communication system that transmits and receives codebook restricting information and the channel station information will be described.

[53] FIG. 4 is a block diagram illustrating a base station and a user equipment in a MIMO wireless communication system according to an embodiment of the present invention. FIG. 5 illustrates a channel between a base station and a user equipment that uses a polarized antenna array of FIG. 4.

[54] Referring to FIG. 4, a MIMO wireless communication system may include a user equipment 410 and a base station 420.

[55] The user equipment 410 includes an antenna array 411 to receive a signal through a downlink channel, a post-decoder 412 to process a received signal and to decode the received signal into original data using a precoding matrix, and a channel information feedback device 414.

[56] The antenna array 411 may use a plurality of antennas. In this example, the antenna array 411 may form a polarized antenna array. The array may be embodied as a dual polarized antenna array in which two antennas having different polarities intersect each other so as to arrange a larger number of antennas in a limited space.

[57] Referring to FIG. 5, when "+" indicates a direction polarizing to the right from the vertical direction and "-" indicates a direction polarizing to the left from the vertical

direction, the user equipment 410 includes a polarized antenna array 411 including two pairs of antennas in which antennas 411aa and 411ab polarized at 45 degrees from the vertical direction and antennas 411ba and 411bb polarized at -45 degrees from the vertical direction intersect to each other, respectively. In this example, the antennas 411aa and 411ab polarized at +45 degrees may be referred to as a first domain 411a or a first subset of a transmitting side, and the antennas 411ba and 411bb polarized at -45 degrees may be referred to as a second domain 411b or a second subset of the transmitting side.

[58] Referring again to FIG. 4, the post-decoder 412 may correspond to a first precoder 422 and a second precoder 424 of the base station 420. The post-decoder may transfer a received reference signal to the channel information feedback device 414.

[59] The channel information feedback device 414 may receive a reference signal and may estimate a channel using the reference signal. The channel information feedback device 414 may generate channel information including 1st channel status information and 2nd channel station information. The channel information feedback device 414 may feed back the channel information to the base station 420.

[60] The base station 420 may include a layer mapper 421 to map a codeword to a layer, a precoder 425 to perform precoding of data symbols obtained through the layer mapping using a precoding matrix, and an antenna array 428 to transmit a precoded signal on air. The precoder 425 may include the first precoder 422 and the second precoder 424 to perform precoding of data symbols. In this example, the first precoder 422 and the second precoder 424 may perform precoding of data symbols using a corresponding first precoding matrix and a corresponding second precoding matrix, respectively.

[61] The antenna array 428 of the base station 420 may use a plurality of antennas. In this example, the antenna array 428

may form a polarized antenna array. An array may be embodied as a dual polarized antenna array in which two antennas having different polarities intersect each other so as to arrange a larger number of antennas in a limited space in a wireless communication system. In this example, although it is described that the antenna arrays 411 and 428 use a dual polarized antenna array, this may not be limited thereto.

[62] Referring to FIG. 5, the base station 420 includes a polarized antenna array 428 including four pairs of antennas in which antennas 428aa through 428ad polarized at 45 degrees from the vertical direction and antennas 428ba through 428bd polarized at -45 degrees intersect each other, respectively. In this example, the antennas 428aa through 428ad polarized at +45 degrees are referred to as a first domain 428a or a first subset of a receiving side, and the antennas 428ba through 428bd polarized at -45 degrees are referred to as a second domain 428b or a second subset of a receiving side.

[63] When a phase mismatch does not exist between polarized antennas of the user equipment 410 and the base station 420, an overall channel H may be expressed as shown in Equation 1.

[64] [Equation1]

[65]

$$H = \begin{bmatrix} H_h & 0 \\ 0 & H_v \end{bmatrix}$$

[66] In this example, H_h denotes a channel between the first subset or the first domain 411a of the user equipment 410 and the first subset or the first domain 428a of the base station 420, and H_v denotes a channel between the second subset or the second domain 411b and the second subset or the second domain 428b of

the base station 420.

[67] As shown in Equation 1, when antennas polarized to different directions intersect each other and have no phase mismatch, the antennas may not affect each other. Therefore, only H_h and H_v may be estimated and thus, a channel may be recognized. When a distance d between adjacent polarized antennas is shorter than a signal wavelength λ, a correlation between antennas may be high. In this example, H_h and H_v may be determined based on a distance d between antennas and an incident angle θ of signal propagation that arrives at the user equipment 410.

[68] When a phase mismatch exists between polarized antennas of the user equipment 410 and the base station 420, for example, when pairs of antennas of the user equipment 410 are tilted to the left by ε, signals transmitted from each polarized domain of the base station 420 may be received by two polarized domains of the user equipment 410 and thus, inter-domain interference may occur due to a phase mismatch between the domains. Therefore, a channel may be affected by a degree of a phase error or a phase mismatch between polarized antennas of the user equipment 410 and the base station 420, that is, by ε, and thus, the overall channel H may be expressed by Equation 2.

[69] [Equation 2]

[70]

$$H = \begin{bmatrix} H_h \cos\varepsilon & -H_v \sin\varepsilon \\ H_h \sin\varepsilon & H_v \cos\varepsilon \end{bmatrix}$$

[71] Referring again to FIG. 4, the second precoder 424 may

correct a phase mismatch to remove an effect from a phase error or a phase mismatch between polarized domains formed by the antenna array 428 including antennas intersecting in a horizontal direction and a vertical direction, and the first precoder may perform intra-domain precoding.

[72] When a dual polarized domain is configured based on a scheme of arranging two antennas at the same location, each polarized domain may have an identical spatial channel characteristic. That is, each domain may be precoded based on an identical precoding matrix ($H_h = H_v = R_0$), and a signal transmitted through each polarized domain may have a different phase and size when arriving at the user equipment 410. In this example, a first precoding matrix and a second precoding matrix used in the first precoder 422 and the second precoder 424 may be expressed by Equation 3.

[73] [Equation 3]

[74]

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

[75] In Equation 3, R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

[76] A size of a signal received in each domain may be determined by a precoding gain of R_0 of a first precoding matrix W_1, a second precoding matrix W_2 corrects a phase mismatch between signals received in respective domains. When an operation proceeds in this manner, a first index PMI_1 for setting the first

precoding matrix W_1 and a second index PMI_2 for setting the second precoding matrix W_2 may be independently selected.

[77] As shown in Equation 3, the precoder 425 is a precoder configured of a first precoding matrix that performs precoding using R_0 determined by a precoding gain in each of the two domains (a polarized domain or a subset of antennas) and a second precoding matrix that performs phase mismatch correction (co-phasing) between domains. Therefore, each of the two independent domains may be precoded by R_0 determined by a precoding gain, and one of the domains may be phase-corrected by $\wedge$ and may be transmitted.

[78] In the precoder 425, the second precoding matrix corresponds to a precoding matrix that corrects signal attenuation caused by a phase error between polarized domains in polarized antennas. Also, the second precoding matrix may correspond to a precoding matrix to correct signal attenuation caused by a phase error between polarized domains, or may correspond to a precoding matrix to correct a phase mismatch that naturally occurs between polarized antennas. The base station 420 stores a first codebook that expresses N (N is a natural number greater than or equal to 1) first precoding matrices used for the first precoder 422 and first indices indexing the first precoding matrices, and a second codebook that expresses M (M is a natural number greater than or equal to 1) second precoding matrices and second indices indexing the second precoding matrices.

[79] Table 2 and Table 3 correspond to examples of the first codebook and the second codebook that use 16 precoding matrices and 4 precoding matrices for each rank, respectively, when the antenna array 428, including 8 dual polarized antennas 428a and 428b, simultaneously transmits a total of 8 layers.

[80] [Table 2]

[81]

RI \ PMI_1	0	1	2	.....	15
1	b0	b1	b2	.....	b15
2	b16	b17	b18	.....	b31
.....	.....	.....	.....	.....	.....
8	b112	b113	b114	.....	b127

[82] [Table 3]

[83]

RI \ PMI_2	0	1	2	3
1	c0	c1	c2	c3
2	c4	c5	c6	c7
.....	.....	.....	.....	.....
8	c28	c29	c30	c31

[84] The base station 420 stores a restriction book including ranks and an index (hereinafter referred to as a restriction index) corresponding to each pair of a first index and a second index for each rank. Table 4 corresponds to a restriction book that uses 16 precoding matrices and 4 precoding matrices for each rank when the antenna array 428, including 8 dual polarized antennas 428a and 428b, simultaneously transmits a total of 8 layers.

[85] [Table 4]

[86]

RI \ (PMI_1 PMI_2)	(0.0)	(0.1)	(0.2)	(0.3)	(1.0)	(1.1)	.....	(15.1)	(15.2)	(15.3)
1	a0	a 1	a 2	a 3	a4	a5	.....	a61	a62	a63
2	a64	a65	a66	a67	a68	a69	.....	a125	a126	a127
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	a448	a449	a450	a451	a452	a453	.....	a509	a510	a511

[87] In a case of codebook restriction, when codebook restricting information is transmitted based on a bitmap format that designates whether each precoding matrix is to be used using one bit, a total of 16x4x8=512 bits may be required for the ranks and pairs of a first index and a second index for respective ranks.

[88] However, as described in the foregoing, a first index PMI_1 for setting a first precoding matrix W_1 and a second index PMI_2 for setting a second precoding matrix W_2 may be independently selected and thus, a codebook may be restricted independently with respect to each precoding matrix, for each rank and for each of the first precoder and the second precoder. Table 5 expresses precoders that are restricted in a restriction book when codebook restriction is determined with respect to the first index=0 (PMI_1=0) and the second index=1 (PMI_2=1) in a rank 1.

[89] [Table 5]

[90]

RI \ (PMI_1, PMI_2)	(0.0)	(0.1)	(0.2)	(0.3)	(1.0)	(1.1)	.....	(15.1)	(15.2)	(15.3)
1	a0	a1	a2	a3	a4	a5	.....	a61	a62	a63
2	a64	a65	a66	a67	a68	a69	.....	a125	a126	a127
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	a448	a449	a450	a451	a452	a453	.....	a509	a510	a511

[91] Although not illustrated in Table 5, a codebook restriction may be independently performed on a first precoding matrix and a second precoding matrix with respect to 8 ranks, in the same manner as the codebook restriction performed on the rank 1.

[92] The base station 420 determines a precoding matrix to be used/not used for each cell or for each user equipment, and transmits codebook restricting information associated with the precoding matrix to be not used to the user equipment 410. In this example, the codebook restricting information may include first information that restricts a precoding matrix from being used as a first precoding and second information that restricts a precoding matrix from being used as a second precoding matrix in the first and second codebooks for each layer.

[93] As shown in Table 5, when codebook restriction on a first index=0 (PMI_1=0) and a second index=1 (PMI_2=1) is determined with respect to the rank 1, codebook restricting information may include [0111111111111111] corresponding to first information and [1011] corresponding to second information in a bitmap format. As described in the foregoing, a corresponding order of an available precoding matrix is expressed to be 1, and a corresponding order of a precoding matrix not to be used is expressed to be 0. Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=0 (PMI_1=0), for example, (PMI_1, PMI_2) = (0,1), (0,1), (0, 2), (0,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=1 (PMI_2=1), for example, (PMI_1, PMI_2) = (0,1), (1,1), …, (14,1), (15,1) in table 5.

[94] When a codebook restriction on a first index=1 (PMI_1=1) and a second index=2 (PMI_2=2) is determined with respect to a rank 2, codebook restricting information may include [1011111111111111].

corresponding to first information and [1101] corresponding to second information. Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=1 (PMI_1=1), for example, (PMI_1, PMI_2) = (1,1), (1,1), (1,2), (1,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=2 (PMI_2=2), for example, (PMI_1, PMI_2) = (0,2), (1,2), …, (14,2), (15,2) in table 5.

[95] When a codebook restriction on a first index=0 (PMI_1=0) and a second index=3 (PMI_2=3) is determined with respect to a rank 8, codebook restricting information may include [0111111111111111] corresponding to first information and [1110] corresponding to second information. Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=0 (PMI_1=0), for example, (PMI_1, PMI_2) = (0,1), (0,1), (0, 2), (0,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=3 (PMI_2=3), for example, (PMI_1, PMI_2) = (0,3), (1,3), …, (14,3), (15,3) in table 5.

[96] In other words, the codebook restricting information includes the first information and the second information. Accordingly, when a first precoding matrix is restricted from being used as a first precoding matrix based on the first information, the use of second precoding matrices that make pairs with the restricted first precoding matrix may be restricted. When a second precoding matrix is restricted from being used as a second precoding matrix based on the second information, the use of first precoding matrices that make pairs with the restricted second precoding matrix may be restricted.

[97] In the same manner, codebook restricting information with respect to each of a rank 3 through a rank 7 may include first

information and second information in a bitmap format. In this example, although the codebook restricting information including the first information and the second information is provided in a bitmap format, this is merely an example and may not be limited thereto.

[98] In the same manner described in the foregoing, when the rank 1 through rank 8 transmit codebook restricting information based on the same bitmap format, a total number of bits of the codebook restricting information that independently restricts a first precoding matrix and a second precoding matrix with respect to a total of 8 ranks may be (16 + 4) x 8 = 160.

[99] The base station 420 may transmit, to the user equipment 410, codebook restricting information that expresses codebook restriction based on a bitmap format using 20 bits for each rank, that is, a total of 160 bits for the rank 1 through the rank 8. The codebook restricting information may be transmitted as downlink control information, for example, an RRC signal, from the base station 420 to the user equipment 410 through a Physical Downlink Shared Channel (PDSCH). In this example, the codebook restricting information may be transmitted from the base station 420 to the user equipment 410 through a Physical Downlink Control Channel (PDCCH) in addition to the PDSCH. In this example, the codebook restricting information may sequentially include first information and second information for each rank. For example, the codebook restricting information may include first information and second information associated with the rank 1, first information and second information associated with the rank 2,…, and first information and second information associated with the rank 8, sequentially.

[100] The codebook restricting information may sequentially include first information for each rank, and then may sequentially include second information for each rank. For example, the codebook restricting information may sequentially

include first information associated with the rank 1 through the rank 8, and then may sequentially include second information associated with the rank 1 through the rank 8. The first information and the second information included in the codebook restricting information may be independently transmitted for each rank from the base station 420 to the user equipment 410. When a codebook is not restricted for a predetermined rank, codebook restricting information associated with the predetermined codebook may not be included.

[101] Accordingly, when a pair of a first index and a second index is restricted, codebook restricting information of a total of 512 bits is required. However, when restriction on a first index and a second index is independently determined and transmitted, an amount of feedback overhead of the codebook restriction may be significantly reduced.

[102] When the first precoder 422 performs intra-domain precoding using a first precoding matrix, for example, in a case where a codebook is restricted so that precoding matrices expressed to be a first index=7 (PMI_1=7) are not to be used since an intra-domain precoding gain is small, any precoding matrix that is expressed to be PMI_1=7 when the second precoder 424 performs phase mismatch correction using a second precoding matrix may not obtain an excellent precoding gain.

[103] That is, determining restriction on a first precoding matrix that performs intra-domain precoding may take precedence over determining restriction on a second precoding matrix that performs phase mismatch correction. Therefore, when a codebook restriction is performed, only the first precoding matrix may be restricted. In this example, the codebook restricting information includes only first information that restricts the first precoding matrix and thus, a total of 16 x 8= 128 bits may be required.

[104] When inter-domain phase mismatch interference takes

precedence in a condition of the same inter-domain interference, only the second precoding matrix may be restricted. In this example, the codebook restricting information includes only second information that restricts the second precoding matrix and thus, a total of 4 x 8 = 32 bits may be required.

[105] As described in the foregoing, a scheme that restricts both the first precoding matrix and the second precoding matrix, independently, a scheme that restricts only the first precoding matrix, and a scheme that restricts only the second precoding matrix may be selectively used. In this example, the base station 420 may transmit, to the user equipment 410, a restriction mode indicator of a total of 2 bits that indicates a restriction mode.

[106] The channel information feedback device 414 of the user equipment 410 determines a first precoding matrix excluding precoding matrices that are restricted from being used as a first precoding matrix based on first information included in codebook restricting information, and reports/feeds back, to the base station 420, 1st channel status information associated with the first precoding matrix. In the example provided in the foregoing, when [0111111111111111] corresponding to first information of a bitmap format that restricts a codebook with respect to a first index = 0 (PMI_1=0) in a rank 1 is received, the channel information feedback device 414 determines a first precoding matrix from among precoding matrices corresponding to indices excluding the first index=0 (PMI_1=0), that is, from among precoding matrices excluding precoding matrices corresponding the first index=0, and reports/feeds back 1st channel status information associated with the first precoding matrix to the base station. Also, each user equipment 410 determines a second precoding matrix excluding matrices that are restricted from being used as a second precoding matrix based on second information included in codebook restricting information,

and reports/feeds back, to the base station 420, 2nd channel status information associated with the second precoding matrix.

In the example provided in the foregoing, when [1011] corresponding to second information of a bitmap format that restricts a codebook with respect to a second index =1 (PMI_2=1) in a rank 2 is received, the channel information feedback device 414 determines a second precoding matrix from among precoding matrices corresponding to indices excluding the second index=1 (PMI_2=1), that is, from among precoding matrices excluding precoding matrices corresponding to the second index=1, and reports/feeds back 2nd channel status information associated with the second precoding matrix to the base station.

[107] When [1011111111111111] corresponding to first information and [1101] corresponding to second information of a bitmap format that restrict a codebook with respect to a first index=1 (PMI_1=1) and a second index=2 (PMI_2=2) in the rank 2 are received, the channel information feedback device 414 determines a first precoding matrix and a second precoding matrix excluding precoding matrices corresponding to the first index=1 (PMI_1=1) and the second index=2 (PMI_2=2) with respect to the rank 2 as shown in Table 5, and reports/feeds back, to the base station, the associated 1st channel status information and 2nd channel status information. In the same manner, the channel information feedback device 414 may determine a first precoding matrix and a second precoding matrix excluding precoding matrices designated by first information and second information, with respect to the rank 3 through the rank 8.

[108] As described in the foregoing, a scheme that restricts both the first precoding matrix and the second precoding matrix, independently, a scheme that restricts only the first precoding matrix, and a scheme that restricts only the second precoding

matrix may be selectively used. When the base station 420 transmits, to the user equipment 410, a restriction mode indicator of a total of 2 bits that indicates a restriction mode, the channel information feedback device 414 of the user equipment 410 may determine a first precoding matrix and a second precoding matrix based on the restriction mode, and generates and reports 1st channel status information and 2nd channel status information.

[109] A feedback period or interval of the 1st channel status information and the 2nd channel status information may be different from each other. For example, the 1st channel status information may be fed back to the base station 420 based on a short term, and the 2nd channel status information may be fed back to the base station 420 based on a long term. In other words, a long period/long term and a short period/short term are relative terms, and the long period/long term indicates a period that is longer than the short period/short term.

[110] The first precoder 422 and the second precoder 424 of the base station 420 determine first and second precoding matrices based on/using channel status information reported from each user equipment 410, and perform precoding of data symbols using the precoding matrices.

[111] The MIMO wireless communication system that transmits and receives codebook restricting information and channel status information according to another embodiment of the present invention has been described. Hereinafter, a communication method of a transmitting device according to another embodiment of the present invention will be described.

[112] FIG. 6 is a flowchart illustrating a communication method of a transmitting device according to another embodiment of the present invention.

[113] Referring to FIG. 6, a communication method 600 of a transmitting device according to another embodiment of the present invention includes a layer mapping step S610 to map a

codeword to a layer, a precoding step S620 to perform precoding of symbols, and a transmitting step S630 to propagate a precoded symbol into air through two or more antennas. The layer mapping step S610, the precoding step S620, and the transmitting step S630 are identical as described in the foregoing and thus, detailed descriptions thereof will be omitted.

[114] A communication method 600 of a base station according to another embodiment of the present invention independently performs codebook restriction on a first precoding matrix of Table 3 and a second precoding matrix of Table 4 with respect to each rank by referring to Table 5, and transmits, to the user equipment 410, codebook restricting information that expresses codebook restriction in a bitmap format using 20 bits for each rank, that is, a total of 160 bits from a rank 1 through a rank 8. The codebook restricting information may be transmitted as downlink control information, for example, an RRC signal, from the base station 420 to the user equipment 410 through a Physical Downlink Shared Channel (PDSCH). In this example, the codebook restricting information may be transmitted from the base station 420 to the user equipment 410 through another channel such as a Physical Downlink Control Channel (PDCCH) in addition to the PDSCH.

[115] In the layer mapping step S610, the codebook restricting information may be mapped to a layer as a downlink control signal.

[116] The base station 420 determines a precoding matrix to be used/not to be used for each cell or each user equipment, and transmits codebook restricting information associated with the precoding matrix to the user equipment 410. In this example, the codebook restricting information includes first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix in first and second

codebooks for each layer.

[117] As shown in Table 5, when codebook restriction is determined with respect to a first index=0 (PMI_1=0) and a second index=1 (PMI_2=1) in a rank 1, codebook restricting information may include [0111111111111111] corresponding to first information and [1011] corresponding to second information in a bitmap format.

[118] The precoding step S620 may perform precoding of a data symbol obtained through layer mapping, using a first precoding matrix and a second precoding matrix selected from a corresponding codebook. In this example, the precoding step S620 may perform precoding of data symbols using a first precoding matrix and a second precoding matrix corresponding to a first index and a second index received from a receiving device such as a user equipment. In this example, the first index and the second index received from the receiving device may correspond to indices associated with precoding matrices selected from precoding matrices excluding precoding matrices that are restricted based on the codebook restricting information in the first codebook of Table 3 and the second codebook of Table 4.

[119] As described in the foregoing, the transmitting device such as a base station may include at least one antenna pair in which at least one antenna polarized in one direction and at least one antenna polarized in another direction intersect each other.

[120] In this example, as described with reference to Equation 3, a first precoding matrix performs precoding between one antenna and another antenna that intersect each other, and a second precoding matrix performs phase mismatch correction between one antenna and another antenna.

[121] The communication method of the transmitting device has been described. Hereinafter, a communication method of a receiving device will be described.

[122] FIG. 7 is a flowchart illustrating a communication method of a receiving device according to another embodiment of the present invention.

[123] A communication method 700 of a receiving device may include a codebook restricting information receiving step S710 to receive codebook restricting information from a transmitting device, and a channel information transmitting step S720 to transmit 1st channel status information and 2nd channel status information to the transmitting device.

[124] The codebook restricting information receiving step S710 may receive first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix for each layer. In this example, the codebook restricting information includes first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix in a first codebook and a second codebook for each layer. The channel information transmitting step S720 transmits, to the transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix being selected, based on codebook restricting information, from precoding matrices that are not restricted from being used as a first precoding matrix or a second precoding matrix in a codebook.

[125] Step S710 and step S720 will be described in detail in the following. When the receiving device receives [0111111111111111] corresponding to first information and [1011] corresponding to second information in a bitmap format that restrict a codebook with respect to a first index=0 (PMI_1=0)

in a rank 1 in step S710, the receiving device determines a first precoding matrix from among precoding matrices corresponding to indices excluding the first index=0 (PMI_1=0), that is, from among precoding matrices excluding precoding matrices corresponding to the first index=0, as shown in Table 5, and reports/feeds back associated 1st channel status information to a base station, and determines a second precoding matrix from among precoding matrices corresponding to indices excluding the second index=1 (PMI_2=1), that is, from among precoding matrices excluding precoding matrices corresponding to the second index = 1, and reports/feeds back associated 2nd channel status information to the base station in step S720.

[126] Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=0 (PMI_1=0), for example, (PMI_1, PMI_2) = (0,1), (0,1), (0, 2), (0,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=1 (PMI_2=1), for example, (PMI_1, PMI_2) = (0,1), (1,1), …, (14,1), (15,1) in table 5.

[127] When the receiving device receives [1011111111111111] corresponding to first information and [1101] corresponding to second information of a bitmap format that restrict a codebook with respect to a first index = 1 (PMI_1=1) and a second index = 2 (PMI_2=2) in a rank 2 in step S710, the receiving device determines a first precoding matrix and a second precoding matrix excluding precoding matrices corresponding to the first index = 1 (PMI_1=1) and the second index = 2 (PMI_2=2) for the rank 2 as shown in Table 5, and reports/feeds back associated 1st channel status information and associated 2nd channel status information to the base station in step S720.

[128] Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=1

(PMI_1=1), for example, (PMI_1, PMI_2) = (1,1), (1,1), (1, 2), (1,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=2 (PMI_2=2), for example, (PMI_1, PMI_2) = (0,2), (1,2), …, (14,2), (15,2) in table 5.

[129] In other words, the codebook restricting information includes the first information and the second information. Accordingly, when a first precoding matrix is restricted from being used as a first precoding matrix based on the first information, the use of second precoding matrices that make pairs with the restricted first precoding matrix may be restricted. When a second precoding matrix is restricted from being used as a second precoding matrix based on the second information, the use of first precoding matrices that make pairs with the restricted second precoding matrix may be restricted.

[130] In the same manner, the receiving device may determine a first precoding matrix and a second precoding matrix for each of a rank 3 through a rank 8, excluding precoding matrices designated by first information and second information.

[131] The process in which a base station and a user equipment exchange codebook restricting information and channel status information in a wireless communication system when a codebook is restricted in a case where a multistage precoder is used, a MIMO wireless communication system that transmits and receives codebook restricting information and channel status information, and the transceiving method or communication method of the transmitting device and the receiving device in the wireless communication system have been described.

[132] According to the embodiments of the present invention, information to restrict precoding matrices is determined for each multistage precoder, and codebook restricting information including the determined information is transmitted and thus, an amount of transmission overhead of the codebook restricting

information may be reduced. According to the embodiments of the present invention, the wireless communication system uses the codebook restriction scheme and thus, inter-cell interference may be controlled.

[133] According to a definition of a precoding matrix as described with reference to Equation 3, a precoding gain in each domain or a subset of an antenna is determined by a first precoding matrix. That is, an overall precoding gain is determined by a gain associated with the first precoding matrix and a coding gain of a second precoder matrix that performs phase mismatch correction (co-phasing) between domains or subsets. In this example, the second precoding matrix performs phase mismatch correction (co-phasing) between domains or subsets and thus, a maximum precoding gain that each user equipment is able to obtain may be determined by the first precoding matrix. In other words, power or receivable maximum power of a signal that each user equipment receives is determined by a first precoder or a first precoding matrix, and a second precoder or a second precoding matrix performs only phase correction of a signal received by each domain or subset of an antenna. Interference by multiple-access may be significantly affected by a first precoder or a first precoding matrix.

[134] FIGS. 8 through 10 are conceptual diagrams illustrating a process of controlling inter-cell interference using a codebook restriction scheme in a wireless communication system according to embodiments of the present invention.

[135] Referring to FIG. 8, inter-cell interference may occur among cell edge user equipments 810a through 810d during beamforming. For example, user equipments 810a and 810b exist in a coverage of a first base station and a second base station as shown in FIG. 8 and thus, when a signal is transmitted that is precoded based on a first precoding matrix associated with a $PMI_1=4$ or $PMI_1=6$ of the first base station of a first cell 820a,

transmission of a signal that is precoded based on a first precoding matrix associated with a PMI_1=13 of the second base station or a second cell 820b may cause interference.

[136] In other words, the user equipments 810a and 810b receive both the transmitted signal that is precoded based on the first precoding matrix associated with the PMI_1=4 or PMI_1=6 of the first base station or the first cell 820a and the transmitted signal that is precoded based on the first precoding matrix associated with a PMI_1=13 of the second base station or the second cell 820b and thus, interference may occur.

[137] Also, user equipments 810c and 810d exist in a coverage of the first base station and the second base station as shown in FIG. 8 and thus, when a signal is transmitted that is precoded based on a first precoding matrix associated with a PMI_1=8 of the first base station 820a, transmission of a signal that is precoded based on a first precoding matrix associated with a PMI_1=2 or a PMI_1=11 of the second base station 820b may cause interference.

[138] The descriptions may be specifically provided using the user equipment 810b as an example as follows. The user equipment 810b receives a signal from both the first base station 820a and the second base station 820b as shown in FIG. 8. The first base station 820a transmits a signal using the first precoding matrix corresponding to the PMI_1=6 to transmit a signal to the user equipment 810b, and the second base station 820b uses the first precoder matrix corresponding to the PMI_1=13 to transmit a signal to the user equipment 810b. Accordingly, as illustrated in FIG. 8, when the second base station 820b transmits a signal to the user equipment 810b using the PMI_1=13, another user equipment 810a may receive multiple-access interference by the signal transmitted to the user equipment 810b.

[139] When the second base station 820b restricts a codebook so that the first precoder matrix corresponding to the PMI_1=13 is

not to be used, the user equipment 810b receives a signal from only the first base station 820a and thus, inter-cell interference due to multiple-interference may be prevented in advance.

[140] Other user equipments 810c and 810d may receive multiple-access interference due to inter-cell interference, like the user equipments 810a and 810b.

[141] When the first base station 820a restricts a codebook so that the first precoder matrix corresponding to the PMI_1=8 is not to be used, user equipments 810c and 810d receive a signal from only the second base station 820b and thus, inter-cell interference due to multiple-interference may be prevented in advance.

[142] FIG. 9 conceptually illustrates a case in which a first precoding matrix or an associated index that is expected to cause inter-cell interference is restricted by performing a codebook restriction based on the above-mentioned scheme, and a downlink MIMO is performed based on the restriction.

[143] Referring to FIG. 9, when each base station 820a and 820b performs a PMI_1=13 based codebook restriction that restricts the use of a first precoding matrix corresponding to a PMI_1=13 or a PMI_1=8, occurrence of inter-cell interference may be avoided or reduced as illustrated in FIG. 9. Therefore, when a codebook restriction is applied to only a PMI_1 and is not applied to a PMI_2, inter-cell interference may be removed.

[144] Referring to FIG. 10, the user equipment 810b receives signals precoded based on a first precoding matrix associated with a PMI_1=6 of a first base station and a first precoding matrix associated with a PMI_1=13 of a second base station and thus, interference may occur. The user equipment 810c receives signals precoded based on a first precoding matrix associated with a PMI_1=8 of the first base station and a first precoding matrix associated with a PMI_1=2 of the second base station and

thus, interference may occur. In this example, the first base station may allow the use of the PMI_1=6 and may restrict the use of the PMI_1=2, and conversely, the second base station may allow the use of the PMI_1=2 and may restrict the use of the PMI_1=6 and thus, interference between user equipments may be removed.

[145] As another example, to remove interference between user equipments, the first base station may allow the use of the PMI_1=8 and may restrict the use of the PMI_1=13, and conversely, the second base station may allow the use of the PMI_1=13 and may restrict the use of the PMI_1=8.

[146] As another example, to remove interference between user equipments, the first base station may allow the use of the PMI_1=6 and the PMI_1=8 and the second base station may restrict the use of the PMI_1=6 and the PMI_1=8. Conversely, the first base station may restrict the use of the PMI_1=6 and the PMI_1=8 and the second base station may allow the use of the PMI_1=6 and the PMI_1=8.

[147] As described in the foregoing, when each base station 820a and 820b performs the PMI_1 based codebook restriction, occurrence of inter-cell interference may be avoided or reduced.

[148] Also, when codebook restriction is applied with respect to only the PMI_2, there is an advantage in that a codebook is restricted by a small number of bits. Also, no restriction is applied to the PMI_1 that directly controls a precoding gain and thus, more precise precoding is available and a size of a codebook may be reduced.

[149] Although the embodiments of the present invention have been described in detail, the present invention may not be limited thereto.

[150] The embodiments of the present invention may be applied to an up/downlink MIMO system, and may be applied to all up/downlink MIMO systems such as a Coordinated multi-point transmission/reception system (CoMP), a heterogeneous network,

and the like, in addition to a single cell environment.

[151] Although a preferred embodiment of the present invention has been described for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims. Therefore, the embodiments disclosed in the present invention are intended to illustrate the scope of the technical idea of the present invention, and the scope of the present invention is not limited by the embodiment. The scope of the present invention shall be construed on the basis of the accompanying claims in such a manner that all of the technical ideas included within the scope equivalent to the claims belong to the present invention.

[152] **CROSS-REFERENCE TO RELATED APPLICATION**

[153] This application claims priority from and the benefit under 35 U.S.C. §119(a) of Korean Patent Application No. 10-2010-0064573, filed on July 5, 2010 which is hereby incorporated by reference for all purposes as if fully set forth herein. Also, when this application claims the priority benefit of the same Korean Patent Applications from countries in addition to the U.S., the disclosure will be incorporated herein by reference.

Claims

1. A communication method of a transmitting device including a first precoder and a second precoder, the method comprising:

determining first information to restrict a precoding matrix from being used as a first precoding matrix of the first precoder, and second information to restrict a precoding matrix from being used as the second precoding matrix of a second precoder in a corresponding codebook with respect to each layer; and

transmitting, to a receiving device, codebook restricting information including at least one of the determined first information and second information.

2. The method of claim 1, further comprising:

receiving, from the receiving device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix selected by the receiving device based on the codebook restricting information; and

precoding data symbols through the first precoder and the second precoder using the first precoding matrix corresponding to the received 1st channel status information and the second precoding matrix corresponding to the second status information, and transmitting the precoded data symbols.

3. The method of claim 1, wherein the first information and the second information are provided in a bitmap format.

4. The method of claim 1, wherein the use of second precoding matrices that make pairs with the first precoding

matrix is restricted based on the first information, and the use of first precoding matrices that make pairs with the second precoding matrix is restricted.

5. The method of claim 1, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

6. The method of claim 5, wherein the first precoding matrix corresponds to W1 in the following Equation, and the second precoding matrix corresponds to W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

7. The method of claim 5, wherein a number of the antenna pairs corresponds to 4.

8. The method of claim 2, wherein, in receiving of the 1st channel status information and the 2nd channel status information, a period of receiving the 1st channel status information and a period of receiving the 2nd channel status information are different from each other.

9. The method of claim 8, wherein the period of receiving the 1st channel status information is longer than the period of receiving the 2nd channel status information.

10. A transmitting device, the device comprising:

a layer mapper to map a codeword to a layer;

a precoder including a first precoder and a second precoder that performs precoding on a data symbol corresponding to the codeword mapped to the layer by the layer mapper, using a first precoding matrix and a second precoding matrix selected from a corresponding codebook; and

an antenna array to transmit signals output from the precoder,

wherein the codeword includes at least one of first information to restrict a precoding matrix from being used as the first precoding matrix and second information to restrict a precoding matrix from being used as the second precoding matrix in the corresponding codebook with respect to each layer.

11. The device of claim 10, wherein the antenna array receives 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix; and

the first precoder and the second precoder perform precoding on data symbols using the first precoding matrix corresponding to the received 1st channel status information and

the second precoding matrix corresponding to the received 2nd channel status information, respectively.

12. The device of claim 10, wherein the first information and the second information are provided in a bitmap format.

13. The device of claim 10, wherein the use of second precoding matrices that make pairs with the first precoding matrix is restricted based on the first information, and the use of first precoding matrices that make pairs with the second precoding matrix is restricted based on the second information.

14. The device of claim 10, wherein the antenna array includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

15. The device of claim 14, wherein the first precoding matrix corresponds to W1 in the following Equation, and the second precoding matrix corresponds to W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

16. The device of claim 14, wherein the first domain and the second domain intersect each other.

17. The device of claim 14, wherein a number of the antenna pairs corresponds to 4.

18. A communication method of a receiving device in a wireless communication system, the method comprising:

receiving codebook restricting information including at least one of first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix for each layer; and

transmitting, to a transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix being selected, based on the codebook restricting information, from among precoding matrices that are not restricted from being used as the first precoding matrix or the second precoding matrix in a

codebook.

19. The method of claim 18, wherein the first information and the second information are provided in a bitmap format.

20. The method of claim 18, wherein the use of second precoding matrices that make pairs with the first precoding matrix is restricted based on the first information and the use of first precoding matrices that make pairs with the second precoding matrix is restricted based on the second information.

21. The method of claim 18, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

22. The method of claim 21, wherein the first precoding matrix corresponds to W1 in the following Equation and the second precoding matrix corresponds to W1 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical

spatial channel status, I denotes a unit matrix, and ^ denotes a phase mismatch correction value between the first domain and the second domain.

23. The method of claim 18, wherein, in transmitting, a period of transmitting the 1st channel status information and a period of transmitting the 2nd channel status information are different from each other.

24. The method of claim 23, wherein the period of transmitting the 1st channel status information is longer than the period of transmitting the 2nd channel status information.

25. A receiving device in a wireless communication system, the device comprising:

an antenna array to receive, as codebook restricting information, at least one of first information to restrict a precoding matrix from being used as a first precoding matrix and first information to restrict a precoding matrix from being used as a second precoding matrix with respect to each layer; and

a channel information feedback device to transmit, to a transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix being selected, based on the codebook restricting information, from among precoding matrices that are not restricted from being used as the first precoding matrix of the second precoding matrix in a codebook.

26. The device of claim 25, wherein the first information and the second information are provided in a bitmap format.

27. The device of claim 25, wherein the use of second

precoding matrices that make pairs with the first precoding matrix is restricted based on the first information and the use of first precoding matrices that make pairs with the second precoding matrix is restricted based on the second information.

28. The device of claim 25, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

29. The device of claim 28, wherein the first precoding matrix corresponds to W1 in the following Equation, and the second precoding matrix corresponds to W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

30. The device of claim 25, wherein a period of transmitting the 1st channel status information and a period of

transmitting the 2nd channel status information are different from each other.

31. The device of claim 30, wherein the period of transmitting the 1st channel status information is longer than the period of transmitting the 2nd channel status information.

Abstract

An embodiment of the present invention relates to a wireless communication system, and more specifically relates to a wireless communication system using multi-input and multi-output (MIMO) antennas in all transmission and reception terminals.

FIG. 1

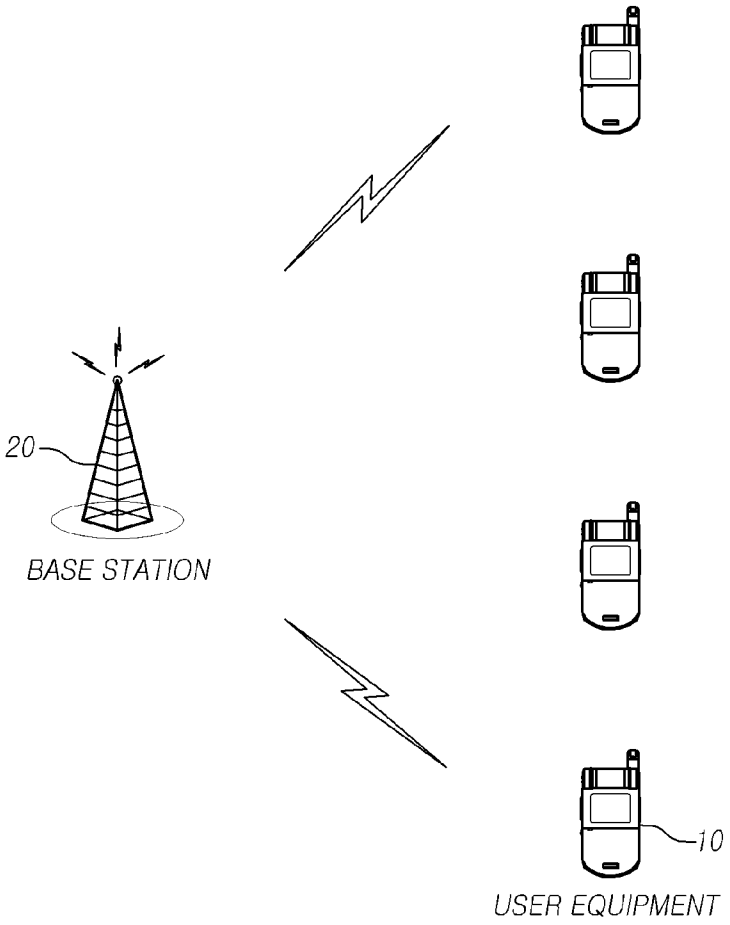
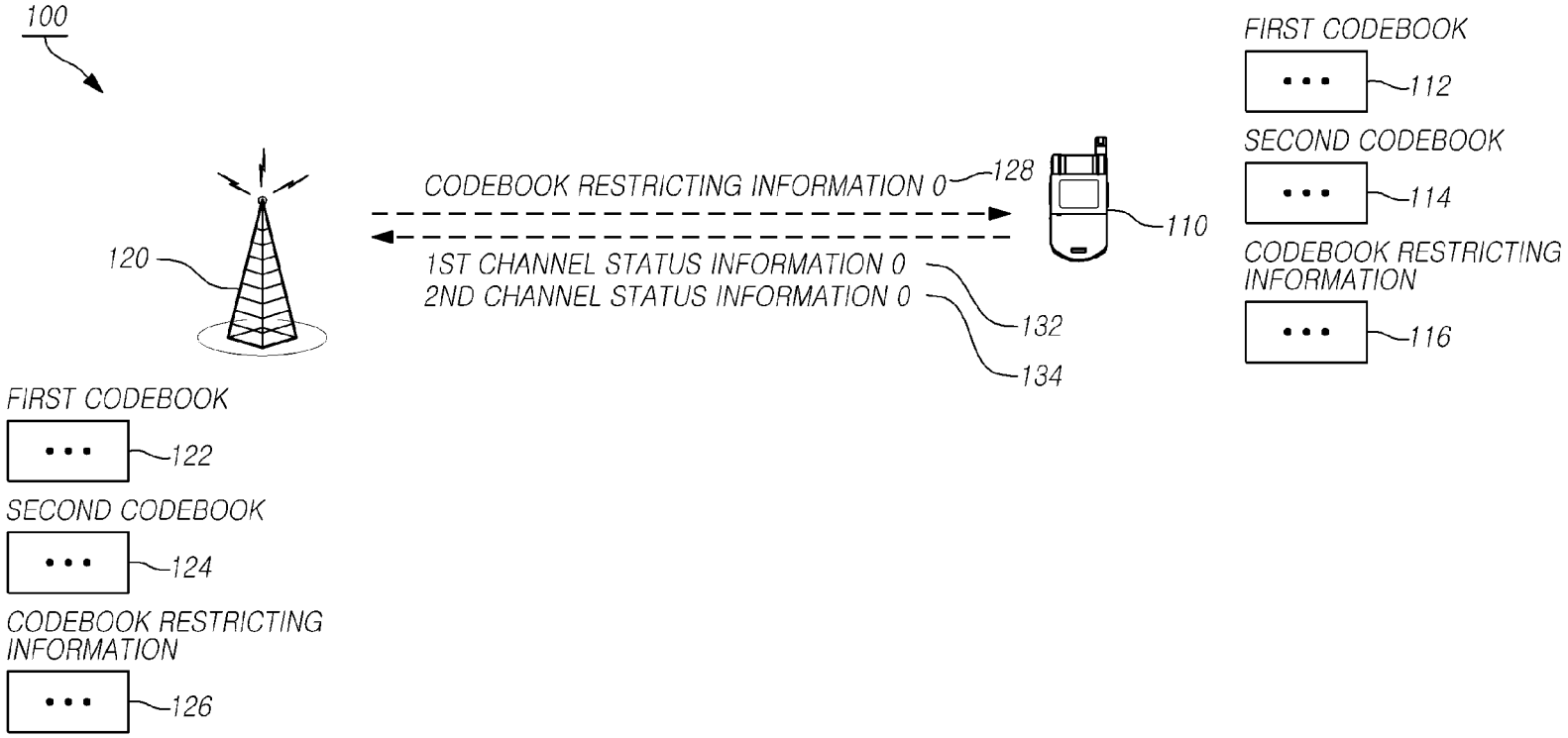


FIG.2



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FIG.3

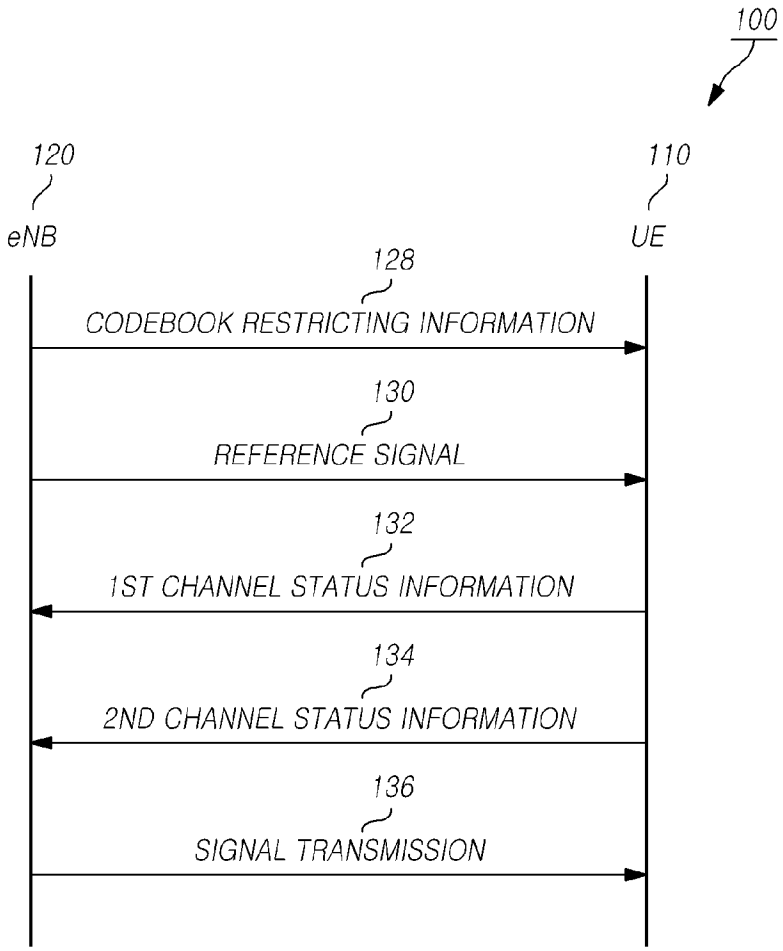

100
120
eNB
110
UE
128
CODEBOOK RESTRICTING INFORMATION
130
REFERENCE SIGNAL
132
1ST CHANNEL STATUS INFORMATION
134
2ND CHANNEL STATUS INFORMATION
136
SIGNAL TRANSMISSION

FIG.4

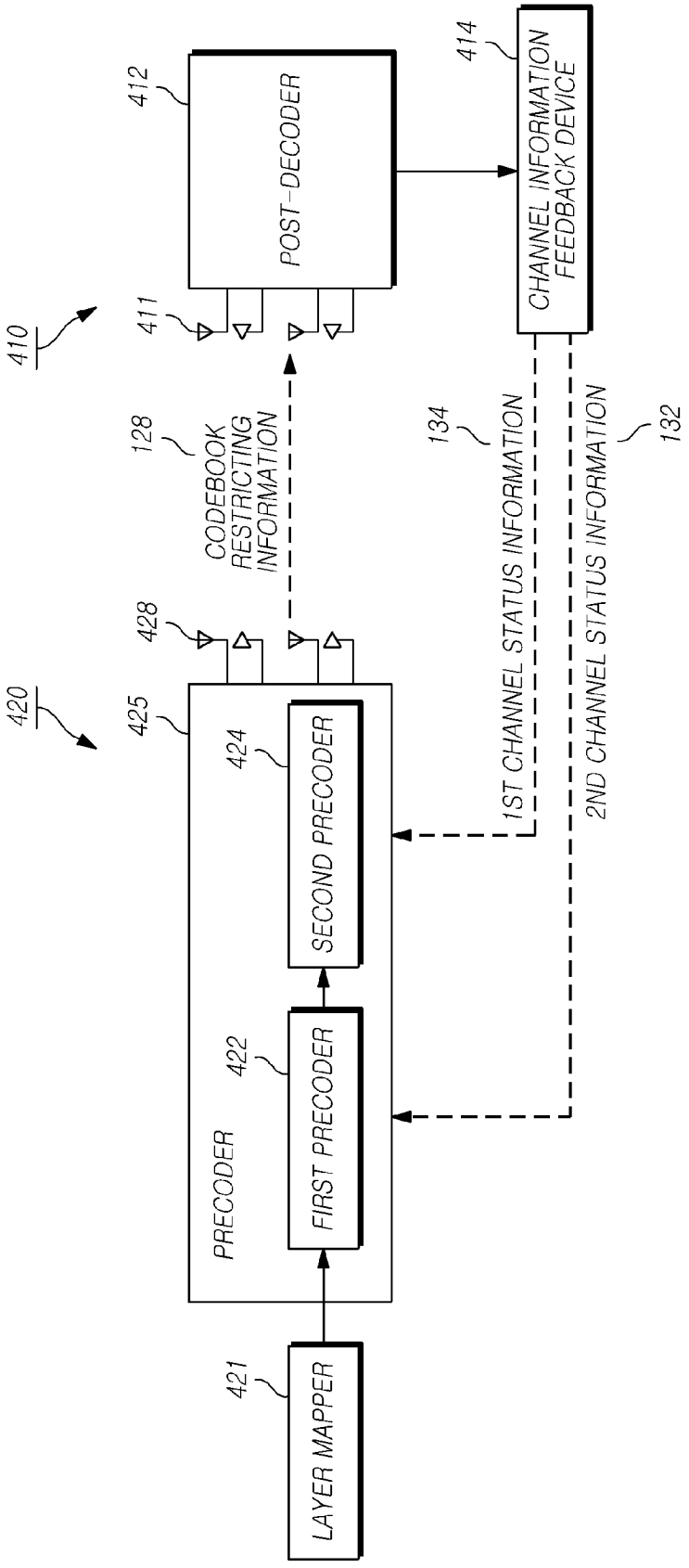
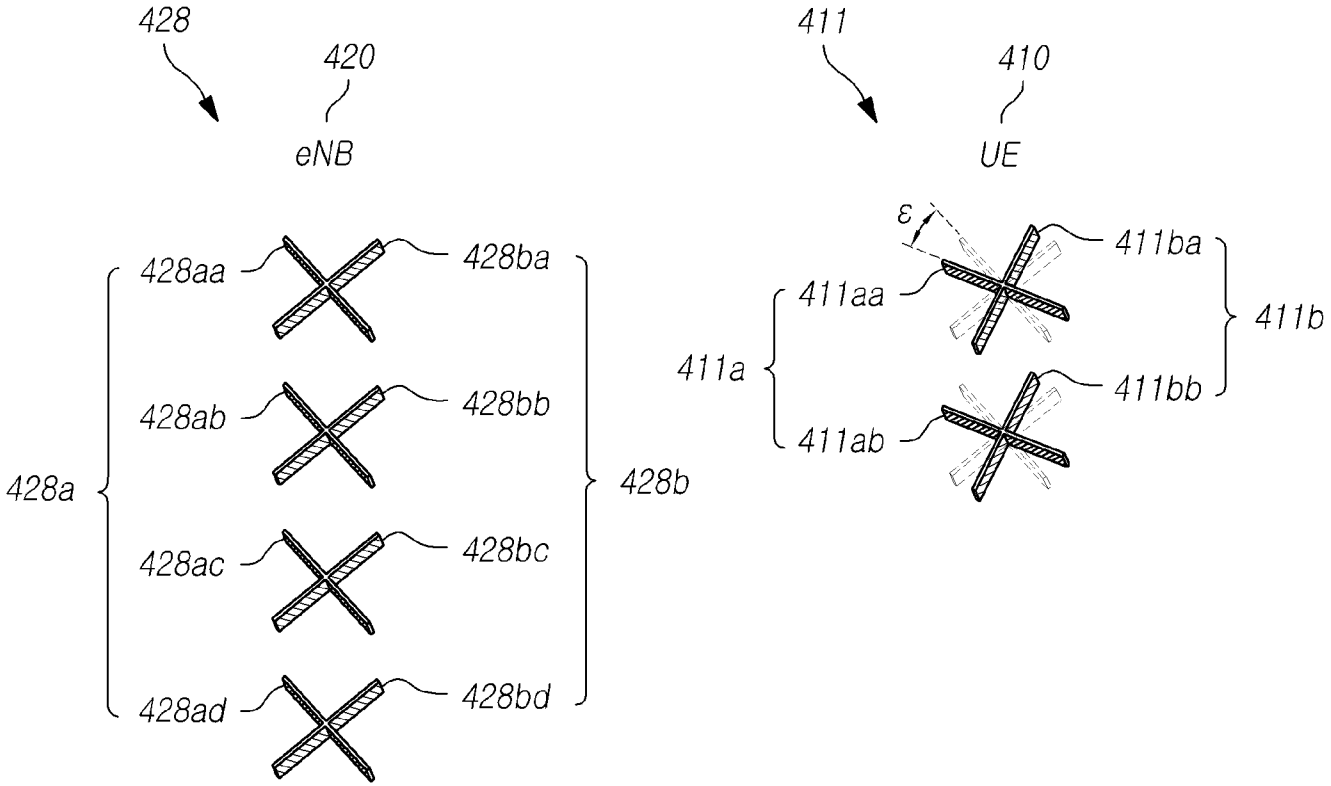

410
411
412
POST-DECODER
414
CHANNEL INFORMATION FEEDBACK DEVICE
128
CODEBOOK RESTRICTING INFORMATION
134
1ST CHANNEL STATUS INFORMATION
132
2ND CHANNEL STATUS INFORMATION
420
425
428
424
SECOND PRECODER
422
FIRST PRECODER
PRECODER
421
LAYER MAPPER

FIG.5



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FIG.6

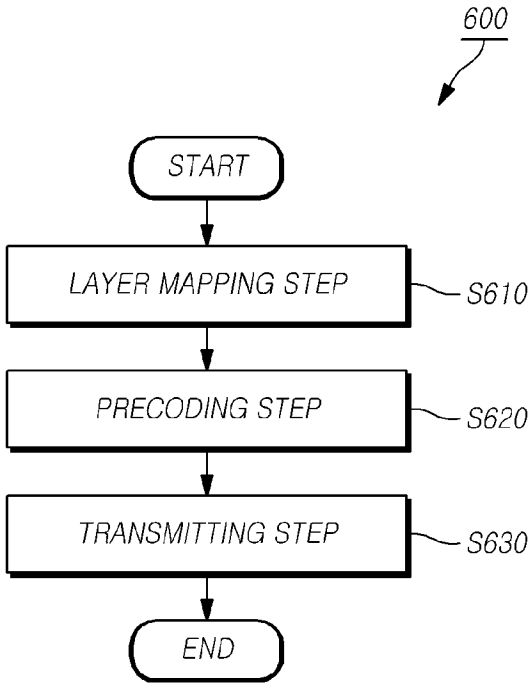

600
START
LAYER MAPPING STEP
S610
PRECODING STEP
S620
TRANSMITTING STEP
S630
END

FIG. 7

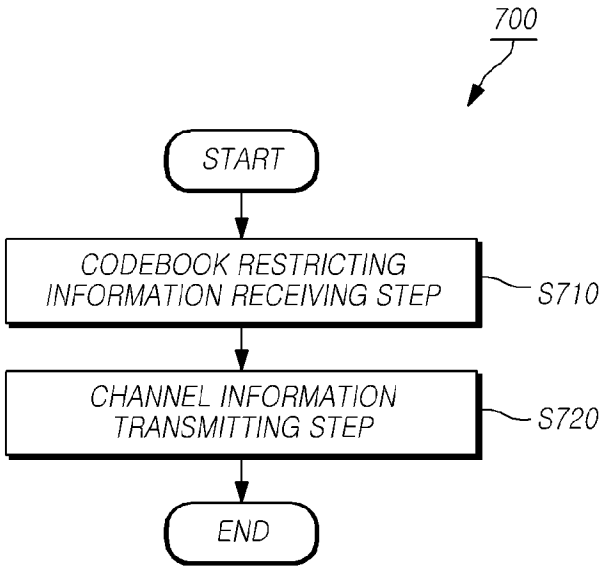

700
START
CODEBOOK RESTRICTING INFORMATION RECEIVING STEP
S710
CHANNEL INFORMATION TRANSMITTING STEP
S720
END

FIG.8

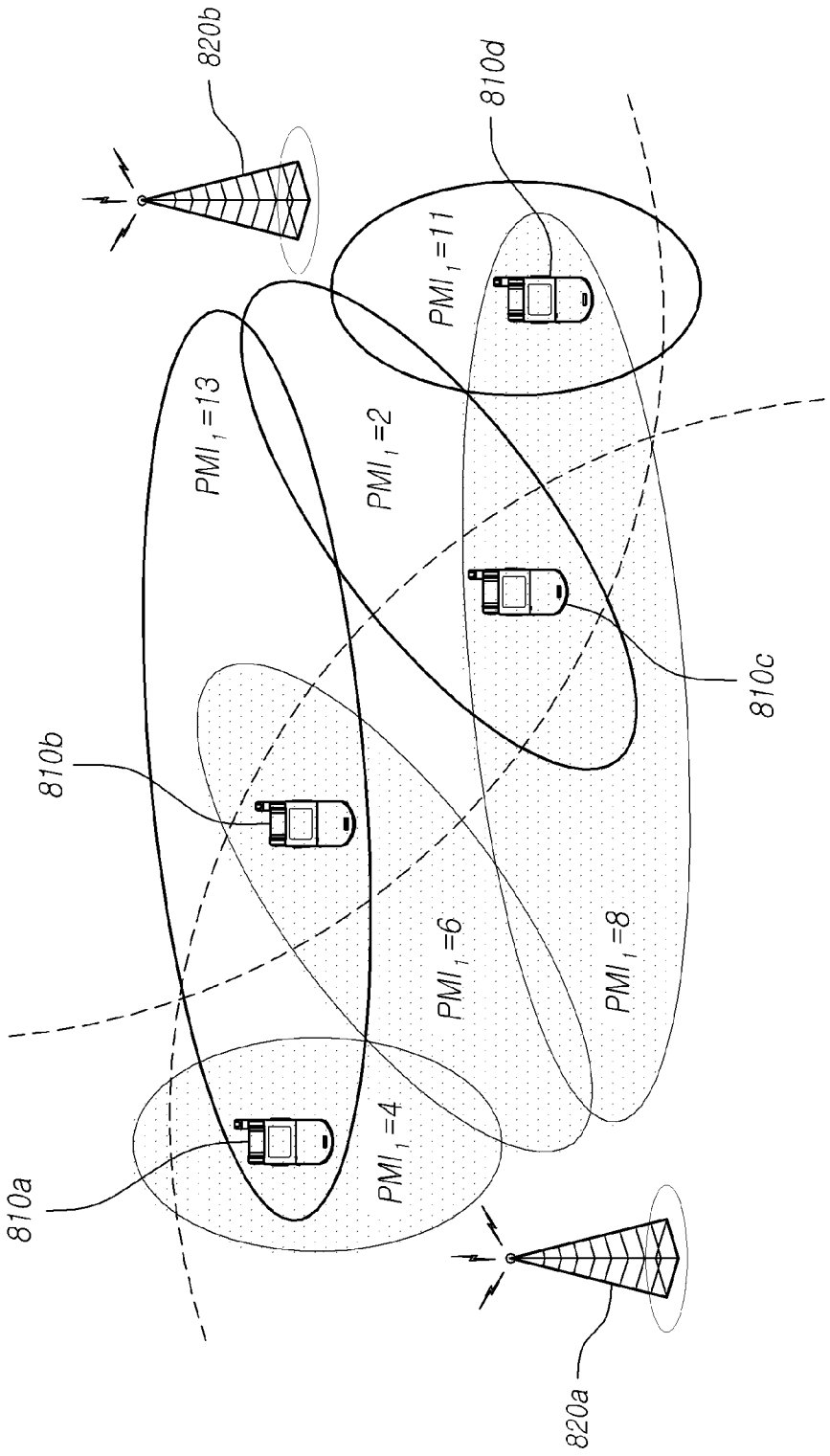

820b
810d
PMI1=11
PMI1=13
PMI1=2
810b
810c
PMI1=6
PMI1=8
PMI1=4
810a
820a

FIG. 9

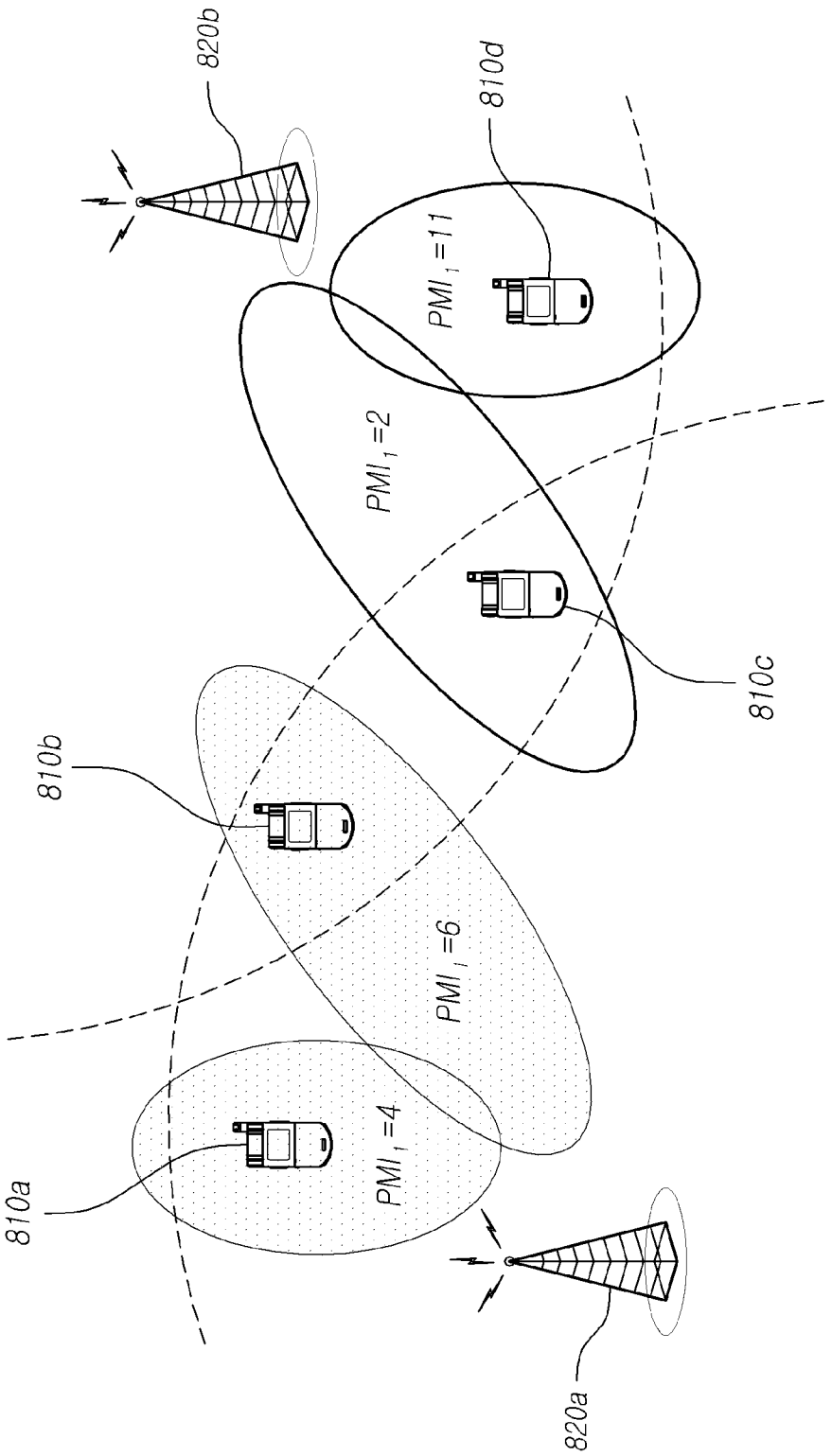
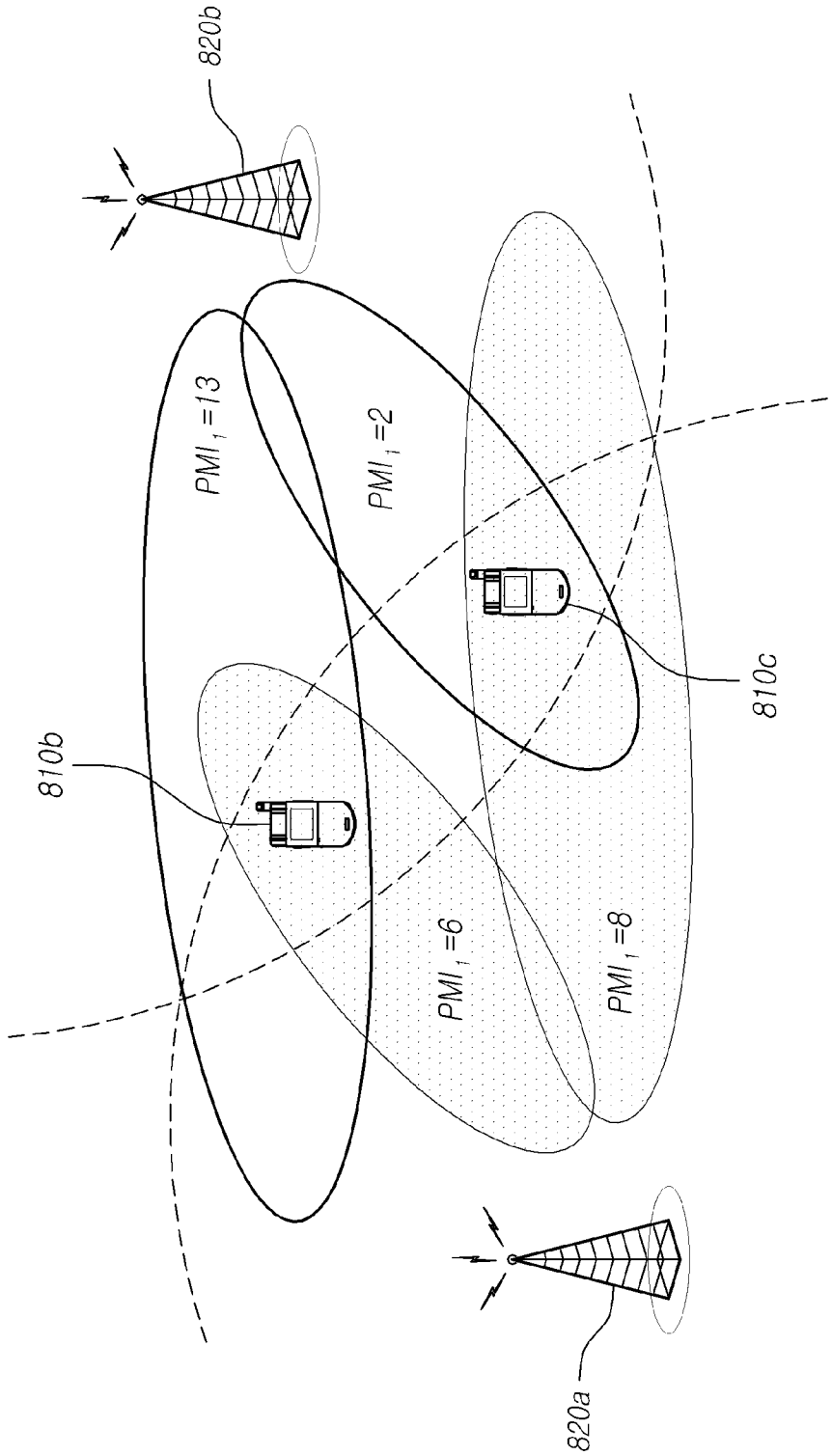


FIG. 10



PTO/SB/08a (01-10)
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Application Number	
Filing Date	2012-12-28
First Named Inventor	Kyoungmin PARK
Art Unit	
Examiner Name	
Attorney Docket Number	P5158US00

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	1	20100048233		2010-02-25	KIM et al.	
	2	20110116563		2011-05-19	VITTHALADEVUNI et al.	
	3	20090257383		2009-10-15	LEE et al.	Corresponds to WO 2009-125956

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	1	2009-125956	WO		2009-10-15	LG ELECTRONICS INC. et al.	Corresponds to US 20090257383	☐

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	1	International Search Report dated December 28, 2011 issued for related International Application No. PCT/ KR2011/004835.	☐

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	Application Number	
	Filing Date	2012-12-28
	First Named Inventor	Kyoungmin PARK
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	Examiner Name	
	Attorney Docket Number	P5158US00

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Name/Print	Hae-Chan Park	Registration Number	50114

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15 October 2009 (15.10.2009)

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61/151,161	9 February 2009 (09.02.2009)	US

(71) Applicant *(for all designated States except US)*: **LG ELECTRONICS INC.** [KR/KR]; 20, Yeouido-dong, Yeongdeungpo-gu, Seoul 150-721 (KR).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **LEE, Wook Bong** [KR/KR]; LG Institute, Hogye 1(il)-dong, Dongan-gu, Anyang-si, Gyeonggi-do 431-080 (KR). **CHUN, Jin Young** [KR/KR]; LG Institute, Hogye 1(il)-dong, Dongan-gu, Anyang-si, Gyeonggi-do 431-080 (KR). **PARK, Sung Ho** [KR/KR]; LG Institute, Hogye 1(il)-dong, Dongan-gu, Anyang-si, Gyeonggi-do 431-080 (KR). **LEE, Moon Il** [KR/KR]; LG Institute, Hogye 1(il)-dong, Dongan-gu, Anyang-si, Gyeonggi-do 431-080 (KR). **KO, Hyun Soo** [KR/KR]; LG Institute, Hogye 1(il)-dong, Dongan-gu, Anyang-si, Gyeonggi-do 431-080 (KR). **IHM, Bin Chul** [KR/KR]; LG Institute, Hogye 1(il)-dong, Dongan-gu, Anyang-si, Gyeonggi-do 431-080 (KR).

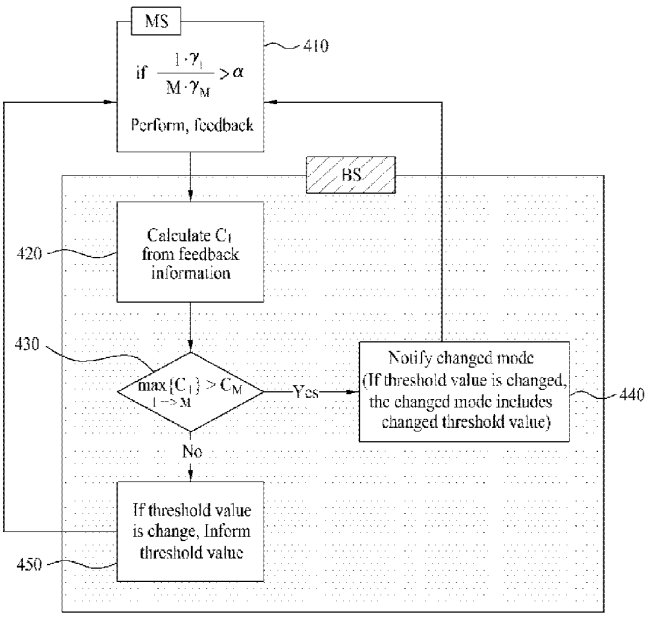
(74) Agents: **KIM, Yong In** et al.; KBK & Associates, 7th Floor, Hyundae Building, 175-9, Jamsil-dong, Songpa-ku, Seoul 138-861 (KR).

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[Continued on next page]

(54) Title: FEEDBACK METHOD FOR PERFORMING A FEEDBACK BY USING A CODEBOOK IN MIMO SYSTEM

[Fig. 4]



(57) Abstract: A feedback method for performing a feedback by using a codebook in Multiple Input Multiple Output (MIMO) system includes receiving, by the mobile station, a MIMO mode type information, generating feedback information by using the codebook selected according to the MIMO mode type information, and transmitting the feedback information to the base station. The codebook includes a SU-MIMO codebook and a MU-MIMO codebook, and the MU-MIMO codebook is formed by extracting codebook elements from the SU-MIMO codebook. As a result, the method maximizes a system throughput simultaneously while effectively reducing an amount of feedback information.

WO 2009/125956 A1

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Published:

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

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

Description

FEEDBACK METHOD FOR PERFORMING A FEEDBACK BY USING A CODEBOOK IN MIMO SYSTEM

Technical Field

[1] The present invention relates to a mode adaptation method for a Multi-Input Multi-Output (MIMO) system, and more particularly to a method for reducing an amount of uplink feedback information.

Background Art

[2] Closed-loop MIMO (CL-MIMO) systems, which are adaptively operated according to a channel condition of a user, among all MIMO systems based on a multi-antenna can greatly improve a performance or throughput of an overall system.

[3] The closed-loop MIMO systems can be classified into a codebook based precoding system for reporting a precoding matrix index (PMI) and an analog feedback based precoding system for reporting a channel. The codebook based precoding system and the analog feedback based precoding system may have the following advantages and disadvantages.

[4] The codebook based precoding system requires a small amount of feedback information, has a small number of channel quality indicator or information (CQI) mismatches, and reduces a flashlight effect according to codeword restriction. At this time, the CQI may be measured in either a midamble or common pilots on the basis of complete comprehension of both a precoder and an interferer.

[5] The codebook based precoding system has the following disadvantages. In more detail, the codebook based precoding system has a large number of quantization errors and a low beamforming gain. In order to implement the above-mentioned codebook based precoding system, an appropriate codebook design is needed.

[6] The analog feedback based precoding system reduces the number of quantization errors and acquires a high beamforming gain. On the other hand, the analog feedback based precoding system requires an excessive amount of either feedback information or feedback errors, has a large number of CQI mismatches, and generates the flashlight effect. Specifically, if the analog feedback based precoding is used for a multi-user MIMO system, the CQI can be measured in only dedicated pilots. Also, provided that the analog feedback based precoding system does not recognize the interfering precoder, the mobile station is unable to measure the CQI. In order to implement the analog feedback based precoding system, a sounding channel is needed.

[7] Therefore, the codebook based precoding system has the above-mentioned advantages, such that it has been widely used for a 3GPP LTE system, a WiMAX system,

and a 2GPP2 Ultra Mobile Broadband (UMB) system.

[8] The MIMO systems are classified into a single user MIMO (SU-MIMO) system and a multi-user MIMO (MU-MIMO) system according to methods for allocating the spatial resources.

[9] FIGS. 1 and 2 illustrate block diagrams illustrating transmission structures when data is transferred at two or more spatial multiplexing rates.

[10] FIG. 1 shows a case in which a vertical encoding (or a single codeword (SCW)) are used. FIG. 2 shows another case in which horizontal encoding (or a multi-codeword (MCW)) are used.

[11] The SU-MIMO system allocates all of the spatial resources to only one mobile station (MS). When the SU-MIMO system is operated under a closed-loop MIMO scheme, each mobile station (MS) selects a preferred rank (i.e., a spatial multiplexing rate), and reports the preferred rank, a precoding matrix index (PMI) and a channel quality information (CQI) which are suitable for the selected rank. A base station (BS) allocates only one mobile station (MS) to a resource (i.e., time and frequency) using such feedback information. In this case, the spatial resources are all used by the mobile station (MS). Here, the SCW or MCW may be used as the transmission structure.

[12] The MU-MIMO system is used to allocate spatial resources to a few mobile stations. When the MU-MIMO system is operated under the CL-MIMO scheme, each mobile station (MS) transmits the CQI and the PMI according to MU-MIMO conditions. In this case, the MU-MIMO conditions are a precoding matrix set, MU-MIMO types (PU2RC, ZF-BF, ...), and the like. The base station (BS) selects mobile stations (MSs) satisfying a specific condition using the received information, and allocates the selected mobile stations to a resource (i.e., time and frequency). Here, the transmission structure is set to the MCW.

[13] Generally, if the number of users is small, the SU-MIMO system has a good throughput superior to that of the MU-MIMO system. If the number of users is large, the MU-MIMO system has a good throughput superior to that of the SU-MIMO system. When several users are paired with each other in the MU-MIMO system, if orthogonal pairs of users are found, the throughput of the MU-MIMO system becomes better. The larger the number of users, the higher the probability of generating the orthogonal pairs.

[14] FIG. 3 is a graph showing a comparison of throughput between the SU-MIMO system and the MU-MIMO system.

[15] In FIG. 3, if about 5 or more people are in a cell, the MU-MIMO system has a good throughput superior to that of the SU-MIMO system. This specific point is called an SU-MU switching point. This switching point may occur at different positions according to a channel status, a user status and the like.

[16] In more detail, a throughput of an optimum system must follow envelopes of the SU-MIMO throughput and the MU-MIMO throughput. For this operation, the mobile station (MS) must carry out not only a feedback operation suitable for the SU-MIMO system but also another feedback operation suitable for the MU-MIMO system. As a result, an amount of feedback overhead unavoidably increases.

[17] Generally, a codebook structure is pre-decided. Specifically, in case of the MU-MIMO mode, if the number of users is not very large, a codebook size must be small such that a pairing gain arises. Therefore, the codebook size for the MU-MIMO mode has generally been designed to be smaller than that of the SU-MIMO mode, such that a beamforming gain decreases.

Disclosure of Invention

Technical Problem

[18] Accordingly, the present invention is directed to a mode adaptation method for a MIMO system that substantially obviates one or more problems due to limitations and disadvantages of the related art.

Technical Solution

[19] An object of the present invention is to provide a mode adaptation method for maximizing a system throughput simultaneously while effectively reducing an amount of feedback information.

[20] Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objectives and other advantages of the invention may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[21] To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, 1. A feedback method for performing a feedback by using a codebook in Multiple Input Multiple Output (MIMO) system, the method including: receiving, by the mobile station, a MIMO mode type information; generating feedback information by using the codebook selected according to the MIMO mode type information; and transmitting the feedback information to the base station. The codebook includes a SU-MIMO codebook and a MU-MIMO codebook, and the MU-MIMO codebook is formed by extracting codebook elements from the SU-MIMO codebook.

[22] The MIMO mode type information may be one of the a single-user MIMO (SU-MIMO) mode, a multi user MIMO (MU-MIMO) mode 2 supporting two mobile stations, a MU-MIMO mode 3 supporting three mobile stations and a MU-MIMO

mode 4 supporting four mobile stations.

[23] The feedback method may further include receiving the SU-MIMO codebook and the MU-MIMO codebook.

[24] The feedback method may further include: receiving rank information and codebook size information, and wherein the MU-MIMO codebook is determined according to the rank information and the codebook size information.

[25] A part of elements of the SU-MIMO codebook may be prohibited from being used.

[26] In another aspect of the present invention, there is provided a feedback method for performing a feedback by using a codebook in Multiple Input Multiple Output (MIMO) system, the method including: transmitting, by the base station, a SU-MIMO codebook; transmitting MIMO mode type information; and receiving feedback information by using the codebook selected according to the MIMO mode type information and the SU-MIMO codebook. The codebook includes the SU-MIMO codebook and a MU-MIMO codebook, and the MU-MIMO codebook is formed by extracting codebook elements from the SU-MIMO codebook.

[27] The MIMO mode type information may be one of the a single-user MIMO (SU-MIMO) mode, a multi user MIMO (MU-MIMO) mode 2 supporting two mobile stations, a MU-MIMO mode 3 supporting three mobile stations and a MU-MIMO mode 4 supporting four mobile stations.

[28] The feedback method may further include reporting rank information and codebook size information, and wherein the MU-MIMO codebook is determined according to the rank information and the codebook size information.

[29] A part of elements of the SU-MIMO codebook may be prohibited from being used.

[30] It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

Advantageous Effects

[31] The present invention provides a method for reducing an amount of uplink feedback information using a mode adaptation method of the MIMO system. This method can be applied to a base station, a mobile station and the like of the IEEE 802.16m system. So, the present invention can maximize a system throughput simultaneously while effectively reducing an amount of feedback information.

Brief Description of Drawings

[32] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiments of the invention and together with the description serve to explain the principle of the invention. In the drawings:

[33] FIGS. 1 and 2 illustrate block diagrams illustrating transmission structures when data is transferred at two or more spatial multiplexing rates;

[34] FIG. 3 is a graph showing a comparison of throughput between an SU-MIMO and an MU-MIMO;

[35] FIG. 4 is a flow chart illustrating a method for reducing an amount of feedback information using a mode adaptation method according to one embodiment of the present invention;

[36] FIG. 5 shows a method for transferring information of a preferred mode, instead of a CQI and PMI of a current mode, over a feedback channel at intervals of a specific period;

[37] FIG. 6 shows a method for periodically transferring information of a preferred mode over an additional feedback channel;

[38] FIG. 7 shows an exemplary case for transferring rank information instead of preferred mode information;

[39] FIG. 8 shows a method for requesting a feedback of a specific mode by a base station (BS) and performing the feedback of the requested mode by a mobile station (MS); and

[40] FIG. 9 is a graph illustrating a throughput of a mode adaptation method according to the present invention.

Mode for the Invention

[41] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts. The following embodiments of the present invention may be modified into various formats, and the scope of the present invention is not limited to only the following embodiments and can also be applied to other examples.

[42] FIG. 4 is a flow chart illustrating a method for reducing an amount of feedback information using a mode adaptation method according to the present invention.

[43] In FIG. 4, l is the number of mobile stations (MSs) transferred at one time under a specific mode (l), and M is the number of mobile stations (MSs) transferred at one time under another mode (M).

[44] The mode may be indicated from the base station (BS). The mode may be set to the mode M which is transferred through a downlink control channel such as an IEEE 802.16e's MAP or a submap.

[45] γ_l may be calculated by the mobile station, and may be a capacity or throughput as a metric of the l-th mode. In this case, it is assumed that $l^* \gamma_l$ and $M * \gamma_M$ are called throughput metrics. C_l is a metric calculated by the base station on the basis of a feedback of the mobile station. For example, C_l may be a sum average capacity (SAC)

or a sum average throughput (SAT), etc.

[46] is a threshold value for a feedback. If a specific condition

$$\frac{l \cdot \gamma_l}{M \cdot \gamma_M} > \alpha$$

is provided, the mobile station reporting the *l*-th mode s feedback. may be a value indicated by the base station, a predetermined value, or another value arbitrarily decided by each mobile station.

[47] In FIG. 4, the mobile station determines whether a ratio of a throughput metric of a current mode (M) to a throughput metric of another mode (l) to which a MIMO mode will be switched is higher than a threshold value at step 410. In this case, if the above ratio is higher than the threshold value, the mobile station reports information of the mode (l) to which the MIMO modewill be switched, to the base station.

[48] Next, the base station having received feedback information calculates the sum average throughput metric of the mode (l) using feedback information at step 420, and determines whether the calculated sum average throughput metric is higher than a mode switching threshold value at step 430. FIG. 4 exemplarily shows a sum average throughput metric of a current mode (M) as the mode switching threshold value.

[49] If the sum average threshold metric of the mode (l) is higher than the mode switching threshold value at step 430, the MIMO mode is changed to the mode (l), and the changed MIMO mode, i.e., the mode (l) is notified to the mobile station at step 440. At this time, if the threshold value is changed, information of the changed threshold value is also notified to the mobile station.

[50] In the meantime, if the sum average throughput metric of the mode (l) is equal to or less than the mode switching threshold value, only information of the threshold value, may be notified to the mobile station at step 450.

[51] Each mobile station may report mode information, a mode index, a CQI and/or a PMI and the like to the base station in various ways.

[52] FIG. 5 shows a method for transferring information of a preferred mode, instead of a CQI and PMI of a current mode, through a feedback channel at intervals of a specific period through a feedback channel.

[53] Particularly, if an amount of information of the preferred mode is larger than a capacity of a feedback channel, this preferred mode information may be divisionally transferred several times through the feedback channel. For some examples, the following cases will be described in detail.

[54] Provided that mode indication information is transferred at intervals of four periods, the mobile station transmits feedback information (CQI and/or PMI) of the mode M indicating a current mode at the time indexes 0, 1 and 2 the feedback channel. If another mode (mode l) does not satisfy

$$\frac{l \cdot \gamma_l}{M \cdot \gamma_M} > \alpha$$

at the time index 3 of the feedback channel, the mode M is fed back as a preferred mode by the mobile station, and feedback information (CQI and/or PMI) of the mode M being the current mode is then transferred from the mobile station to the base station. If the mode l satisfies

$$\frac{l \cdot \gamma_l}{M \cdot \gamma_M} > \alpha$$

at the time index 7 of the feedback channel indicating a mode feedback period, feedback information (CQI and/or PMI) of the mode l is transferred to the base station at the time index 8 of the feedback channel. Thereafter, feedback information (CQI and/or PMI) of the mode M indicating the current mode is transferred to the base station. If the current mode M is changed to the mode l at the time index 10 of the feedback channel, the mobile station transmits feedback information (CQI and/or PMI) of the mode l to the base station.

[55] FIG. 6 shows a method for periodically transferring information of a preferred mode through an additional feedback channel.

[56] Referring to FIG. 6, MS reports the CQI and/or PMI of the current mode (mode M) via feedback channel 1, and MS reports feedback information of another mode via feedback channel 2. For example, if another mode (mode l) does not satisfy

$$\frac{l \cdot \gamma_l}{M \cdot \gamma_M} > \alpha$$

at a time index 0 of the feedback channel 2 (denoted by feedback channel (2) time index 0 in FIG. 6) so that the current mode is considered to be an optimum mode, the mobile station reports the mode M as a preferred mode to the base station. If the mode l satisfies

$$\frac{l \cdot \gamma_l}{M \cdot \gamma_M} > \alpha$$

at a time index 1 of the feedback channel 2 (denoted by feedback channel (2) time index 1), the mobile station reports that the mode l is preferred, and then reports the CQI and/or PMI of the mode l at a time index 2 of the feedback channel 2 (denoted by feedback channel (2) time index 2). In this case, the mobile station may report a preferred mode instead of reporting the CQI and/or PMI of the mode l at the time index 2 of the feedback channel 2, and may also transmit the CQI and/or PMI of the mode l through another channel.

[57] If another mode satisfies

$$\frac{l \cdot \gamma_l}{M \cdot \gamma_M} > \alpha$$

according to an event trigger scheme, the following two methods may be used.

[58] According to a first method, a mobile station requests an additional feedback channel from a base station, and transmits the CQI and/or PMI of the mode 1 through a feedback channel allocated by the base station. According to a second method, if a mobile station has data to be transferred to an uplink, it attaches the CQI and/or PMI of the mode (1) to the channel of the data, and transmits the attached result to the uplink.

[59] FIG. 7 shows an exemplary case for transferring rank information instead of preferred mode information.

[60] If a current mode is set to the SU-MIMO mode, the mobile station may transmit rank information instead of the CQI and/or PMI of the mode M (SU-MIMO).

[61] If the SU-MIMO rank adaptation period (i.e., a period for selecting a preferred rank by the mobile station) is set to 4, the mobile station transfers its own preferred rank at intervals of four time indexes of feedback channel (1). At this time, if the preferred rank is changed to another rank e.g., rank 2 in Fig. 7, the mobile station transmits the CQI and/or PMI suitable for the changed rank via additional feedback channel, e.g., feedback channel (2). Meanwhile, the CQI and/or PMI suitable for the changed rank may be transmitted via the feedback channel (1) through which the information of the changed rank is transmitted at a period when the information of the changed rank is transmitted without allocating an additional feedback channel for the CQI and/or PMI.

[62] In this case, the base station may allocate an additional feedback channel for the rank information.

[63] FIG. 8 shows a method for requesting a feedback of a specific mode by a base station (BS) and performing the feedback of the requested mode by a mobile station (MS).

[64] Referring to FIG. 8, the base station may request a feedback of the mode (1) from the mobile station. In other words, under the condition that the current mode is the mode (M) and some mobile stations perform a feedback of information of the mode (1), if the base station requires more information of the mode (1), it may ask the mobile station to feed back the information of the mode (1). In this case, a feedback may be performed as follows. In more detail, the mobile station reports information of a corresponding mode only once or a predetermined number of times requested by the base station, and then reports information of a current mode. Specifically, if an amount of information of the requested mode is larger than a capacity of a current feedback channel, this requested mode information may be divisionally transferred several times through the feedback channel. In the meantime, if the base station asks the mobile station to perform a feedback of information of another mode using the event trigger scheme, the following methods may be used. According to a first method, the base station allocates a new feedback channel, and transmits the CQI and/or PMI of the requested mode through this newly-allocated feedback channel (i.e., an additional feedback channel).

According to a second method, if the mobile station has data to be transferred to an uplink, it attaches the CQI and/or PMI of the requested mode to a channel of the data, and transmits the attached result to the uplink.

[65] As described above, if a user is located at a cell edge (hereinafter referred to as a cell-edge user), the user may be operated using the SU-MIMO scheme or another MIMO scheme (e.g., a collaborative MIMO scheme) regardless of a mode of the cell. In this case, the feedback may also be adjusted to the corresponding scheme. Specifically, in case of using a fractional frequency reuse (FFR) method, the FFR method allocates a specific frequency band to a cell edge, reports only the specific frequency band (the corresponding FFR band) according to the SU-MIMO scheme or the collaborative MIMO scheme, and may also report the remaining bands using a mode applied to a current cell in the same manner as in the above-mentioned description.

[66] In the meantime, some codebook elements are extracted from the SU-MIMO codebook set on the condition that a codebook is limited, such that the MU-MIMO codebook may be constructed.

[67] In association with the MU-MIMO codebook, it is assumed that the number of transmission (Tx) antennas is set to N_t.

[68] At this time, the mode may include the SU-MIMO mode, an MU-MIMO mode having a rank 2, an MU-MIMO mode having a rank 3, ..., an MU-MIMO mode having a rank N_t, etc. A precoding matrix set of each mode can be represented by the following equation 1.

[69] [Equation 1]

[70] SU-MIMO

[71] rank1 : $S_1 = \{\{v_{1,1,1}\}, \{v_{1,2,1}\}, \{v_{1,K1,1}\}\}$

[72] rank2 : $S_2 = \{\{v_{2,1,1}, v_{2,1,2}\}, \{v_{2,2,1}, v_{2,2,2}\}, \{v_{2,K2,1}, v_{2,K2,2}\}\}$

[73] ...

[74] rank Nt : $S_{Nt} = \{\{v_{Nt,1,1}, ..., v_{Nt,1,Nt},\}, \{v_{Nt,2,1}, ..., v_{Nt,2,Nt}\}..., \{v_{Nt,K,1}, ..., v_{Nt,KNt,Nt}\}\}$

[75] MU-MIMO with rank2 : $M_2 = \{\{p_{2,1,1}, p_{2,1,2}\}, \{p_{2,2,1}, p_{2,2,2}\}..., \{p_{2,K2',1}, p_{2,K2',2}\}\}$

[76] ...

[77] MU-MIMO with rankNt : $M_{Nt} = \{\{p_{Nt,1,1}, ...,p_{Nt,1,Nt},\}, \{p_{Nt,2,1}, ..., p_{Nt,2,Nt}\}..., \{p_{Nt,K,1}, ..., p_{Nt,KNt',Nt}\}\}$

[78] In Equation 1, K# is a codebook size of the SU-MIMO rank #, and K#'is a codebook size of the MU-MIMO rank #. K# and K#' may be different from each other as necessary.

[79] In this case, the base station may inform the mobile station of the K# and K#' values and constituent entities. If the base station informs the mobile station of only the K# and K#' values, it may use a specific codebook set predetermined for the K# or K#'value.

[80] A codebook of the feedback MU-MIMO can be constructed as follows according to the following two MU-MIMO transmission methods.

[81] The MU-MIMO codebook performing a feedback using the following two methods according to MU-MIMO transmission methods, may be configured.

[82] According to a first method, if a codebook being reporting is different from a codebook transferred from the base station, the MU-MIMO codebook for a feedback toward an uplink may include codebook elements of a rank 1. The base station may use and combine feedback information, such that it may configure another-format precoder. In this case, the rank 1 codebook elements may be a subset of the SU-MIMO rank (1) codebook.

[83] According to a second method, if a feedback codebook is equal to another codebook transferred from the base station, the MU-MIMO codebook for a feedback toward the uplink can be operated as follows. In the MU-MIMO of the rank 2 (denoted by "MU-MIMO with rank 2"), a codebook includes codebook elements of the rank 2. In the MU-MIMO of the rank 3 (denoted by "MU-MIMO with rank 3"), a codebook includes codebook elements of the rank 3.

[84] In this case, a precoding matrix set for each mode can be represented by the following equation 2.

[85] [Equation 2]

[86] SU-MIMO

[87] rank1 : $S_1 = \{\{v_{1,1,1}\}, \{v_{1,2,1}\} ..., \{v_{1,K1,1}\}\}$

[88] rank2 : $S_2 = \{\{v_{2,1,1}, v_{2,1,2}\}, \{v_{2,2,1}, v_{2,2,2}\}..., \{v_{2,K2,1}, v_{2,K2,2}\}\}$

[89] ...

[90] rank Nt : $S_{Nt} = \{\{v_{Nt,1,1}, ..., v_{Nt,1,Nt}\}, \{v_{Nt,2,1}, ..., v_{Nt,2,Nt}\}..., \{v_{Nt,K,1}, ..., v_{Nt,KNt,Nt}\}\}$

[91] MU-MIMO with rank2 : $M_2 = \{\{v_{2,k1,1}, v_{2,k1,2}\}, \{v_{2,k2,1}, v_{2,k2,2}\}...\}$

[92] ...

[93] MU-MIMO with rankNt : $MNt = \{\{v_{Nt,k1,1}, ..., v_{Nt,k1,Nt}\}, \{v_{Nt,k2,1}, ...,v_{Nt,k2,Nt}\}...\}$

[94] In other words, the MU-MIMO codebook may extract some constituent elements from the SU-MIMO codebook of the same rank.

[95] The base station changes the number of codebook elements constructing the MU-MIMO and their constituent entities to others, and may inform the mobile station of both the changed number of codebook elements and the changed constituent entities. For example, in case of a codebook entry, the base station may extract the codebook entry on the basis of SU-MIMO feedback information received from the mobile station, and may broadcast the constructed codebook set to the mobile station. In this case, K#' may be predetermined for each rank, or may be indicated to the mobile station. The constructed codebook includes some parts of preferred codebook indexes of each mobile station. So, although the MU-MIMO system uses a small-sized

codebook set, it can acquire a higher beamforming gain.

[96] Specific constituent elements of the SU-MIMO codebook may not be used due to a request from another cell or other reasons. For example, if another cell mobile station reports that a specific codebook element (e.g., $v_{1,k,l}$) influences greatly due to interference, this constituent element may not be used. In addition, if $\alpha \cdot v_{1,k,l}$ is contained in a codebook of a higher rank, this codebook element may not be also used.

[97] The MU-MIMO operations based on the above-mentioned codebook are as follows.

[98] First, if the rank of the MU-MIMO codebook is equal to a transmission rank, i.e., if the MU-MIMO codebook of the rank 2 is configured in the form of

$$Nt \times 2$$

matrix, the mobile station calculates the CQI using a reception algorithm for each codebook element, and feeds back its own preferred precoding matrix index (PMI), a stream index, a CQI, etc. The base station performs pairing of mobile stations, and applies a corresponding codebook to the paired mobile stations.

[99] Next, if the codebook rank of the MU-MIMO for a feedback toward an uplink is set to 1, i.e., if the MU-MIMO codebook is configured in the form of an

$$Nt \times 1$$

matrix, the mobile station calculates the CQI on the assumption of a single rank transmission (rank1 transmission) for each codebook element, and reports a precoding matrix/vector index, and the CQI. Otherwise, provided that orthogonal or almost-orthogonal codebook elements of individual codebook elements are paired with each other, the mobile station calculates the CQI using a reception algorithm implemented by the MU-MIMO mode. The precoding matrix/vector index and the CQI are reported from the mobile station.

[100] The base station performs pairing of mobile stations using such feedback information, modifies the CQI as necessary, and then selects an MCS level. The base station modifies a precoding matrix according to a selected MU-MIMO algorithm (e.g., ZF-BF, PU2RC, or SDMA), and transmits the modified precoding matrix to each mobile station.

[101] FIG. 9 is a graph illustrating a throughput of a mode adaptation method (SU-MIMO or MU-MIMO) according to the present invention.

[102] As can be seen from FIG. 9, it can be readily recognized that a throughput graph of the mode adaptation method according to one embodiment of the present invention closely follows envelopes indicating optimum throughputs of the SU-MIMO and the MU-MIMO.

[103] Although the present invention has been disclosed by referring to the above-mentioned embodiments, it should be noted that the aforementioned embodiments

have been disclosed for only illustrative purposes, and those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

Industrial Applicability

[104] The present invention relates to a mode adaptation method for a Multi-Input Multi-Output (MIMO) system, and more particularly to a method for reducing an amount of uplink feedback information.

Claims

[1] A feedback method for performing a feedback by using a codebook in Multiple Input Multiple Output (MIMO) system, the method comprising:
receiving, by the mobile station, a MIMO mode type information;
generating feedback information by using the codebook selected according to the MIMO mode type information; and
transmitting the feedback information to the base station,
wherein the codebook includes a SU-MIMO codebook and a MU-MIMO codebook, and the MU-MIMO codebook is formed by extracting codebook elements from the SU-MIMO codebook.

[2] The feedback method according to claim 1, wherein the MIMO mode type information is one of the a single-user MIMO (SU-MIMO) mode, a multi user MIMO (MU-MIMO) mode 2 supporting two mobile stations, a MU-MIMO mode 3 supporting three mobile stations and a MU-MIMO mode 4 supporting four mobile stations.

[3] The feedback method according to claim 1, further comprising:
receiving the SU-MIMO codebook and the MU-MIMO codebook.

[4] The feedback method according to claim 1, further comprising:
receiving rank information and codebook size information, and wherein the MU-MIMO codebook is determined according to the rank information and the codebook size information.

[5] The feedback method according to claim 1,
wherein a part of elements of the SU-MIMO codebook is prohibited from being used.

[6] A feedback method for performing a feedback by using a codebook in Multiple Input Multiple Output (MIMO) system, the method comprising:
transmitting, by the base station, a SU-MIMO codebook;
transmitting MIMO mode type information; and
receiving feedback information by using the codebook selected according to the MIMO mode type information and the SU-MIMO codebook,
wherein the codebook includes the SU-MIMO codebook and a MU-MIMO codebook, and the MU-MIMO codebook is formed by extracting codebook elements from the SU-MIMO codebook.

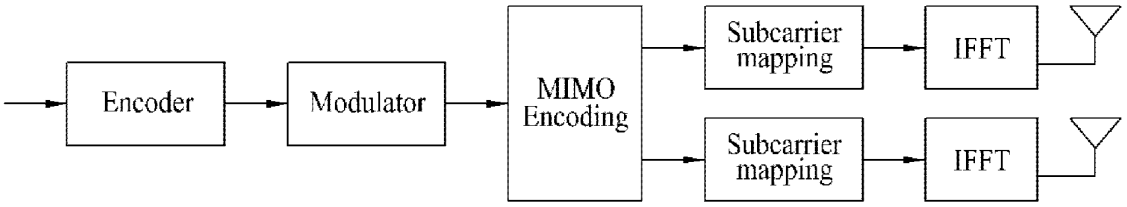
[7] The feedback method according to claim 6, wherein the MIMO mode type information is one of the a single-user MIMO (SU-MIMO) mode, a multi user MIMO (MU-MIMO) mode 2 supporting two mobile stations, a MU-MIMO mode 3 supporting three mobile stations and a MU-MIMO mode 4 supporting

four mobile stations.

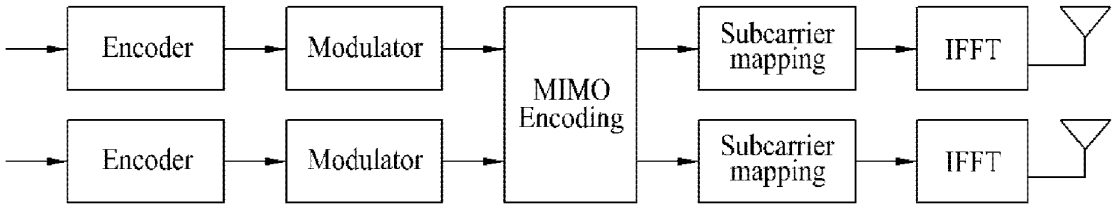
[8] The feedback method accordign to claim 6, further comprising:
reporting rank information and codebook size information, and wherein the MU-MIMO codebook is determined according to the rank information and the codebook size information.

[9] The feedback method according to claim 6,
wherein a part of elements of the SU-MIMO codebook is prohibited from being used.

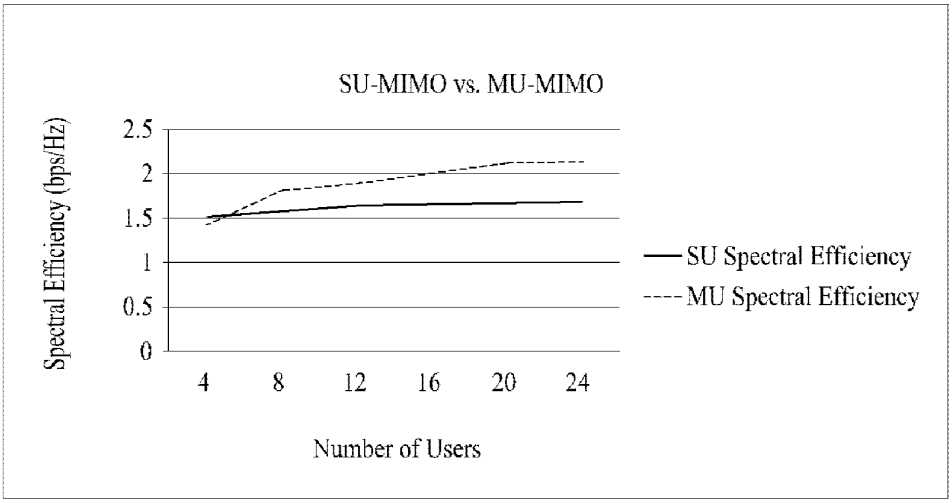
[Fig. 1]



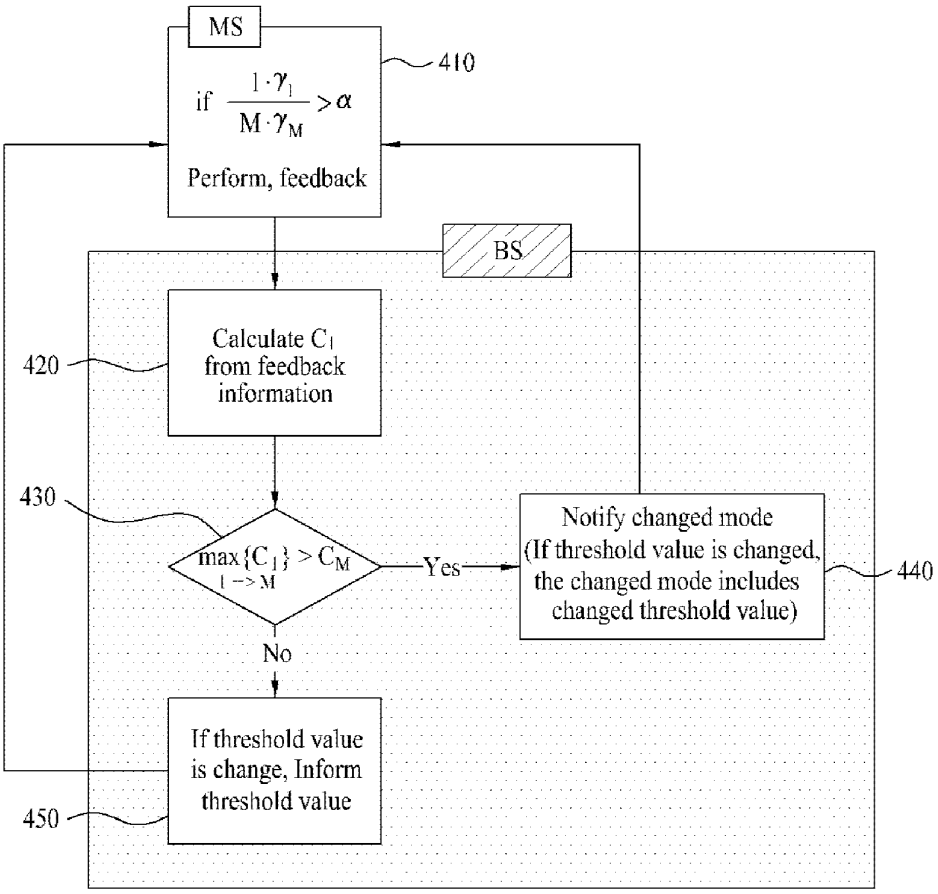
[Fig. 2]



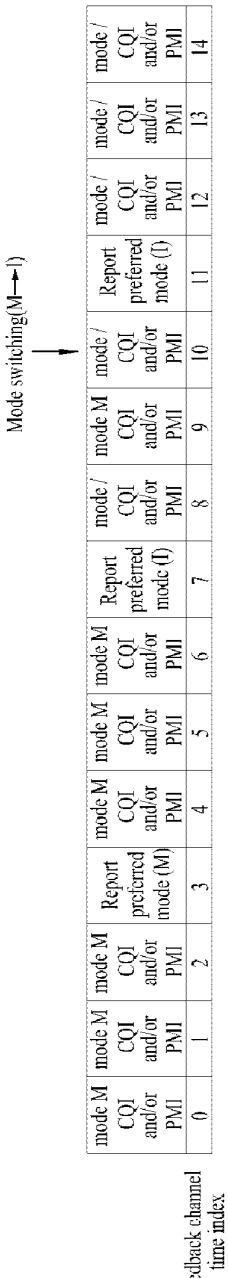
[Fig. 3]



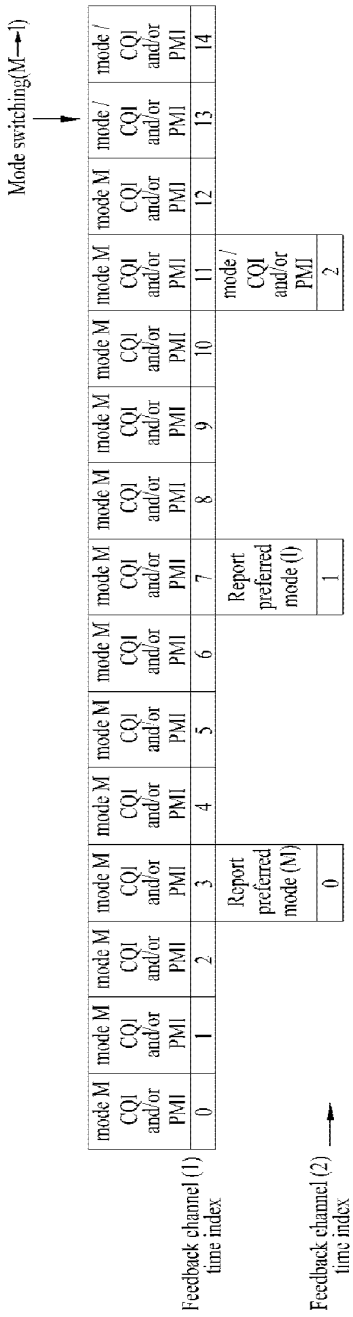
[Fig. 4]


MS
410
if $\frac{1 \cdot \gamma_1}{M \cdot \gamma_M} > \alpha$
Perform, feedback
BS
Calculate C_1 from feedback information
420
430
$\max_{1 \to M}\{C_1\} > C_M$
Yes
Notify changed mode (If threshold value is changed, the changed mode includes changed threshold value)
440
No
If threshold value is change, Inform threshold value
450

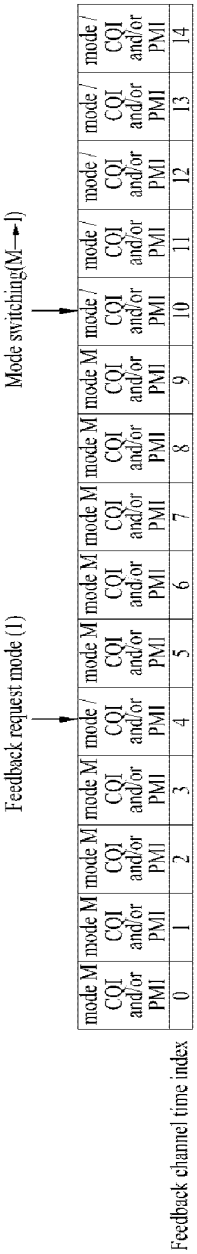
[Fig. 5]


Mode switching(M→1)
Feedback channel time index
mode M CQI and/or PMI
mode M CQI and/or PMI
mode M CQI and/or PMI
Report preferred mode (M)
mode M CQI and/or PMI
mode M CQI and/or PMI
mode M CQI and/or PMI
Report preferred mode (1)
mode / CQI and/or PMI
mode M CQI and/or PMI
mode / CQI and/or PMI
Report preferred mode (1)
mode / CQI and/or PMI
mode / CQI and/or PMI
mode / CQI and/or PMI
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14

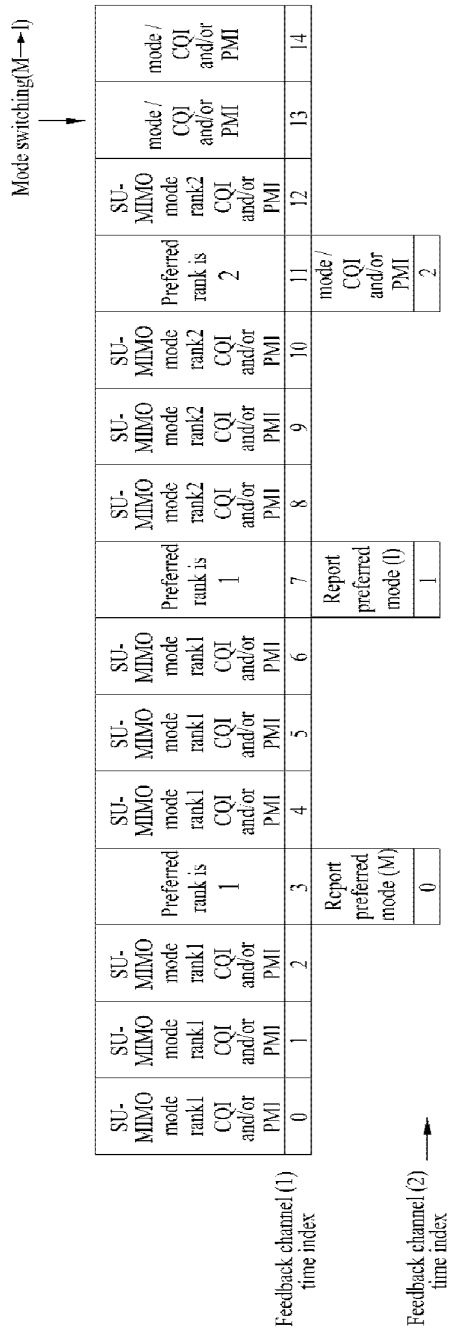
[Fig. 6]


Mode switching(M→1)
mode M CQI and/or PMI
mode / CQI and/or PMI
Feedback channel (1) time index
Feedback channel (2) time index
Report preferred mode (N)
Report preferred mode (1)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14

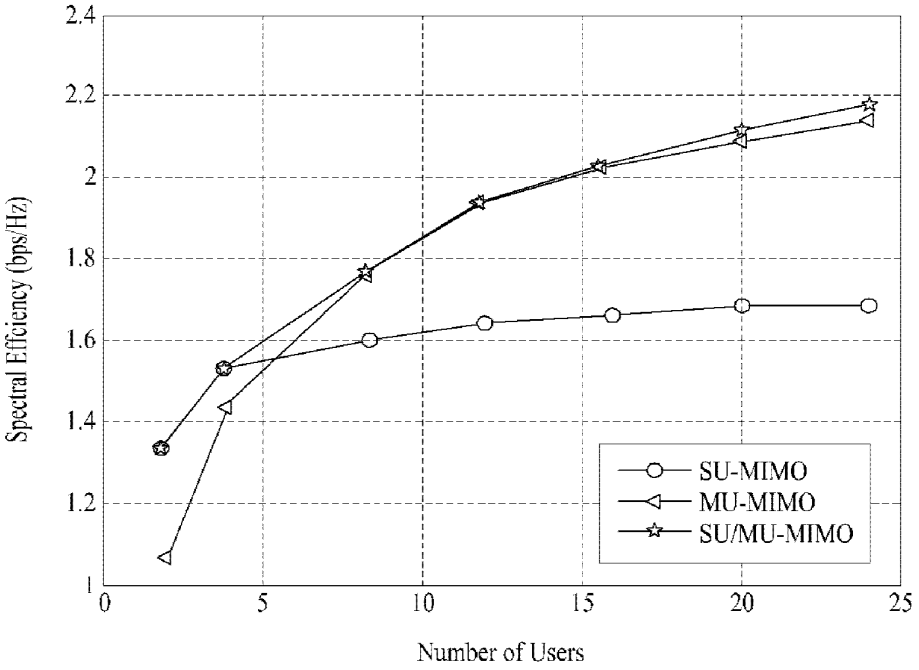
[Fig. 7]


Feedback request mode (1)
Mode switching(M→1)
mode M CQI and/or PMI
mode / CQI and/or PMI
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Feedback channel time index

[Fig. 8]


Mode switching(M→1)
SU-MIMO mode rank1 CQI and/or PMI
SU-MIMO mode rank1 CQI and/or PMI
SU-MIMO mode rank1 CQI and/or PMI
Preferred rank is 1
SU-MIMO mode rank1 CQI and/or PMI
SU-MIMO mode rank1 CQI and/or PMI
SU-MIMO mode rank1 CQI and/or PMI
Preferred rank is 1
SU-MIMO mode rank2 CQI and/or PMI
SU-MIMO mode rank2 CQI and/or PMI
SU-MIMO mode rank2 CQI and/or PMI
Preferred rank is 2
SU-MIMO mode rank2 CQI and/or PMI
mode / CQI and/or PMI
mode / CQI and/or PMI
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Report preferred mode (M)
0
Report preferred mode (1)
1
mode / CQI and/or PMI
2
Feedback channel (1) time index
Feedback channel (2) time index

[Fig. 9]


2.4
2.2
2
1.8
1.6
1.4
1.2
1
0
5
10
15
20
25
Spectral Efficiency (bps/Hz)
Number of Users
SU-MIMO
MU-MIMO
SU/MU-MIMO

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2009/001769

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)

IPC H04B

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

KOREAN UTILITY MODELS AND APPLICATIONS FOR UTILITY MODELS SINCE 1975

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

eKIPASS, DELPHION, ESPACENET & Keywords : SU-MIMO, MU-MIMO, preferred MIMO mode, selection and similar terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2007/105928 A1 (SAMSUNG ELECTRONICS CO., LTD.) 20.09.2007 * See abstract; claims 1-4; Fig.4 *	1-9
A	WO 2003/073646 A1 (QUALCOMM INCORPORATED) 04.09.2003 * See abstract; claims 1,2,4-6,15; Fig.2 *	1-9
A	KR 2006-0022630 A (SAMSUNG ELECTRONICS CO., LTD. et al.) 10.03.2006 * See abstract; claims 1-4,7,14-19 *	1-9
A	WO 2006/093385 A2 (LG ELECTRONICS INC.) 08.09.2006 * See abstract; claims 1-3,9 *	1-9

☐ 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 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	Date of mailing of the international search report
31 JULY 2009 (31.07.2009)	**03 AUGUST 2009 (03.08.2009)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea	KIM Byeong Gyun
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-8300

Form PCT/ISA/210 (second sheet) (July 2008)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2009/001769

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2007/105928 A1	20.09.2007	EP 1994652 A1	26.11.2008
		KR 2007-94442 A	02.04.2008
WO 2003/073646 A1	04.09.2003	AU 2003-213214 A1	09.09.2003
		CN 1653721 A	10.08.2005
		JP 2005-518755 A	23.06.2005
		KR 2004-0091671 A	28.10.2004
		US 2005/0094598 A1	05.05.2005
KR 2006-0022630 A	10.03.2006	EP 1643661 A2	05.04.2006
WO 2006/093385 A2	08.09.2006	CA 2599716 A1	08.09.2006
		EP 1856857 A2	21.11.2007
		KR 2006-0096799 A	13.09.2006

특허협력조약
PCT

국제조사보고서
(PCT 제 18 조 및 PCT규칙 43 및 44)

출원인 또는 대리인의 서류참조기호	추가적인 조치	서식 PCT/ISA/220 및 아래 5.(해당하는경우) 참조
PCT11-354		
국제출원번호	국제출원일 (일/월/년)	(최) 우선일 (일/월/년)
PCT/KR2011/004835	**2011년 07월 01일 (01.07.2011)**	2010년 07월 05일 (05.07.2010)
출원인		
(주)팬택 등		

본 국제조사보고서는 본 국제조사기관에 의하여 작성되었으며 PCT 제18조의 규정에 따라 출원인에게 송부됩니다. 이 국제조사보고서의 사본은 국제사무국에 송부됩니다.

본 국제조사보고서는 총 **4** 매로 구성되어 있습니다.

☐ 본 보고서에서 인용된 각 선행기술 문헌의 사본도 첨부되어 있습니다.

1. **보고서의 기초**
   a. **언어**와 관련하여, 국제조사는 아래에 기초하여 수행되었습니다.
      ☒ 출원시의 언어로 된 국제출원
      ☐ 국제조사를 위해 _____ 로 번역되어 제출된 국제출원의 번역문(PCT규칙 12.3(a) 및 23.1(b))
   b. ☐ 본 국제조사보고서는 PCT규칙 91의 규정에 따라 당해 기관이 허가하였거나 또는 당해 기관에 통보된 **명백한 잘못의 정정**을 고려하여 작성되었습니다(PCT규칙 43.6의2(a)).
   c. ☐ 국제출원에 개시된 **핵산염기 및/또는 아미노산 서열**에 관하여는 제1기재란을 참조하십시오.
2. ☐ **일부 청구항은 조사할 수 없습니다**(제2기재란 참조).
3. ☐ **발명의 단일성이 결여되어 있습니다**(제3기재란 참조).
4. **발명의 명칭**과 관련하여,
   ☒ 출원인이 제출한 대로 승인합니다.
   ☐ 본 국제조사기관이 다음과 같이 발명의 명칭을 작성하였습니다:
5. **요약서**와 관련하여,
   ☐ 출원인이 제출한 대로 승인합니다.
   ☒ PCT규칙 38.2의 규정에 따라 본 기관이 제4기재란에 표시된 대로 요약서를 작성하였습니다. 출원인은 본 국제조사보고서의 발송일부터 1월 이내에 본 기관에 의견를 제출할 수 있습니다.
6. **도면**과 관련하여,
   a. 요약서와 함께 공개될 **도면**은 제 **3** 도이며
      ☒ 출원인이 제안하였습니다.
      ☐ 출원인이 도면의 번호를 제안하지 않았기 때문에 본 기관이 선택하였습니다.
      ☐ 본 도면이 발명의 특징을 더 잘 나타내고 있기 때문에 본 기관이 선택하였습니다.
   b. ☐ 요약서와 함께 공개될 도면이 없습니다.

제4기재란 요약서의 내용(첫 번째 용지의 5의 계속)

이 출원은 송수신단 모두에서 다중입력다중출력(MIMO) 안테나를 이용하는 무선통신시스템에 관한 것이다. 특히, 제1프리코더와 제2프리코더를 포함하는 송신장치에서 자신의 코드북에서 각 레이어에 대해 상기 제1프리코더의 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코더의 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 각각 결정하는 단계 및 결정한 상기 제1정보와 상기 제2정보 중 적어도 하나를 포함하는 코드북제한정보를 수신장치에 전송하는 단계를 기술적 특징으로 포함하고 있다.

국 제 조 사 보 고 서

국제출원번호
PCT/KR2011/004835

A. 발명이 속하는 기술분류(국제특허분류(IPC))

H04B 7/04(2006.01)i

B. 조사된 분야

조사된 최소문헌(국제특허분류를 기재)
H04B 7/04; H04L 27/28; H04B 15/00

조사된 기술분야에 속하는 최소문헌 이외의 문헌
한국등록실용신안공보 및 한국공개실용신안공보: 조사된 최소문헌란에 기재된 IPC
일본등록실용신안공보 및 일본공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

국제조사에 이용된 전산 데이터베이스(데이터베이스의 명칭 및 검색어(해당하는 경우))
eKOMPASS(특허청 내부 검색시스템) & 키워드: 코드북, 제한, 프리코더, 무선통신

C. 관련 문헌

카테고리*	인용문헌명 및 관련 구절(해당하는 경우)의 기재	관련 청구항
A	US 2010-0048233 A1 (KIM YU-SEOK 외 4명) 2010.02.25 요약, 문단 [50] - 문단 [52] 및 도 6 참조.	1-31
A	WO 2009-125956 A1 (LG ELECTRONICS INC. 외 6명) 2009.10.15 요약 및 청구항 1항 참조.	1-31
PX PA	US 2011-0116563 A1 (VITTHALADEVUNI PAVAN KUMAR 외 2명) 2011.05.19 요약, 문단 [78] - 문단 [79] 및 도 19,20 참조.	1,10,18,25 2-9,11-17,19-24 ,26-31

☐ 추가 문헌이 C(계속)에 기재되어 있습니다.

☒ 대응특허에 관한 별지를 참조하십시오.

* 인용된 문헌의 특별 카테고리:

"A" 특별히 관련이 없는 것으로 보이는 일반적인 기술수준을 정의한 문헌

"E" 국제출원일보다 빠른 출원일 또는 우선일을 가지나 국제출원일 이후에 공개된 선출원 또는 특허 문헌

"L" 우선권 주장에 의문을 제기하는 문헌 또는 다른 인용문헌의 공개일 또는 다른 특별한 이유(이유를 명시)를 밝히기 위하여 인용된 문헌

"O" 구두 개시, 사용, 전시 또는 기타 수단을 언급하고 있는 문헌

"P" 우선일 이후에 공개되었으나 국제출원일 이전에 공개된 문헌

"T" 국제출원일 또는 우선일 후에 공개된 문헌으로, 출원과 상충하지 않으며 발명의 기초가 되는 원리나 이론을 이해하기 위해 인용된 문헌

"X" 특별한 관련이 있는 문헌. 해당 문헌 하나만으로 청구된 발명의 신규성 또는 진보성이 없는 것으로 본다.

"Y" 특별한 관련이 있는 문헌. 해당 문헌이 하나 이상의 다른 문헌과 조합하는 경우로 그 조합이 당업자에게 자명한 경우. 청구된 발명은 진보성이 없는 것으로 본다.

"&" 동일한 대응특허문헌에 속하는 문헌

국제조사의 실제 완료일	국제조사보고서 발송일
2011년 12월 28일 (28.12.2011)	**2011년 12월 28일 (28.12.2011)**

ISA/KR의 명칭 및 우편주소
대한민국 특허청
(302-701) 대전광역시 서구 청사로 189,
정부대전청사
팩스 번호 82-42-472-7140

심사관
김병성

전화번호 82-42-481-5652

서식 PCT/ISA/210 (두 번째 용지) (2009년 7월)

국제조사보고서
대응특허에 관한 정보

국제출원번호
PCT/KR2011/004835

국제조사보고서에서 인용된 특허문헌	공개일	대응특허문헌	공개일
US 2010-0048233 A1	2010.02.25	KR 10-2010-0023529 A	2010.03.04
WO 2009-125956 A1	2009.10.15	CN 101981823 A	2011.02.23
		CN 101981824 A	2011.02.23
		CN 101981825 A	2011.02.23
		EP 2245758 A1	2010.11.03
		EP 2248277 A1	2010.11.10
		EP 2248278 A1	2010.11.10
		EP 2340620 A2	2011.07.06
		JP 2011-517524 A	2011.06.09
		JP 2011-518491 A	2011.06.23
		JP 2011-518492 A	2011.06.23
		KR 10-2009-0106975 A	2009.10.12
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		US 2009-0257383 A1	2009.10.15
		US 2009-0257384 A1	2009.10.15
		US 2009-0268698 A1	2009.10.29
		US 2010-0118997 A1	2010.05.13
		US 8045528 B2	2011.10.25
		WO 2009-125954 A1	2009.10.15
		WO 2009-125955 A1	2009.10.15
		WO 2010-050689 A2	2010.05.06
US 2011-0116563 A1	2011.05.19	WO 2011-060299 A2	2011.05.19
		WO 2011-060299 A3	2011.08.25

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2011/004835

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 7/04; H04L 27/28; H04B 15/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

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

eKOMPASS (KIPO internal) & Keywords: code book, restriction, precoder, wireless communication

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010-0048233 A1 (KIM, YU-SEOK et al.) 25 February 2010 See abstract, paragraph [50] - paragraph [52] and figure 6.	1-31
A	WO 2009-125956 A1 (LG ELECTRONICS INC. et al.) 15 October 2009 See abstract and claim 1.	1-31
PX PA	US 2011-0116563 A1 (VITTHALADEVUNI PAVAN KUMAR et al.) 19 May 2011 See abstract, paragraph [78] - paragraph [79] and figures 19,20.	1,10,18,25 2-9,11-17,19-24 ,26-31

☐ 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	Date of mailing of the international search report
28 DECEMBER2011 (28.12.2011)	**28 DECEMBER2011 (28.12.2011)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

Patent document cited in search report	Publication date	Patent family member	Publication date
US 2010-0048233 A1	25.02.2010	KR 10-2010-0023529 A	04.03.2010
WO 2009-125956 A1	15.10.2009	CN 101981823 A	23.02.2011
		CN 101981824 A	23.02.2011
		CN 101981825 A	23.02.2011
		EP 2245758 A1	03.11.2010
		EP 2248277 A1	10.11.2010
		EP 2248278 A1	10.11.2010
		EP 2340620 A2	06.07.2011
		JP 2011-517524 A	09.06.2011
		JP 2011-518491 A	23.06.2011
		JP 2011-518492 A	23.06.2011
		KR 10-2009-0106975 A	12.10.2009
		KR 10-2010-0048845 A	11.05.2010
		US 2009-0257383 A1	15.10.2009
		US 2009-0257384 A1	15.10.2009
		US 2009-0268698 A1	29.10.2009
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PTO/SB/80 (01-06)
Approved for use through 12/31/2008. OMB 0651-0035
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POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(b).

I hereby appoint:

[X] Practitioners associated with the Customer Number: 58027

OR

[ ] Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

as attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignment documents attached to this form in accordance with 37 CFR 3.73(b).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(b) to:

[X] The address associated with Customer Number: 58027

OR

[ ] Firm or Individual Name			
Address			
City		State	Zip
Country			
Telephone		Email	

Assignee Name and Address:
PANTECH CO., LTD.
Pantech R&D Center, I-2, DMC Sangam-dong,
Mapo-gu, Seoul 121-270, Republic of Korea

A copy of this form, together with a statement under 37 CFR 3.73(b) (Form PTO/SB/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(b) may be completed by one of the practitioners appointed in this form if the appointed practitioner is authorized to act on behalf of the assignee, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record
The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature		Date	July 22, 2008
Name	Hwang, Chaddng	Telephone	82-2-2030-0519
Title	IP Team Leader		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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PTO/SB/96 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
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STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: Kyoungmin PARK

Application No./Patent No.: To be assigned Filed/Issue Date: December 28, 2012

Titled: TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

Pantech Co., Ltd. , a Corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.

states that it is:

1. ☒ the assignee of the entire right, title, and interest in;

2. ☐ an assignee of less than the entire right, title, and interest in (The extent (by percentage) of its ownership interest is _____ %); or

3. ☐ the assignee of an undivided interest in the entirety of (a complete assignment from one of the joint inventors was made)

the patent application/patent identified above, by virtue of either:

A. ☒ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy therefore is attached.

OR

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☒ As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/hae-chan park/ December 28, 2012

Signature Date

Hae-Chan Park (Reg.# 50,114) Attorney

Printed or Typed Name Title

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Attorney's Docket No.: P5158US00

ASSIGNMENT

Whereas, Assignor has invented certain new and useful processes, machines, articles of manufacture, compositions of matter, and/or improvements thereof ("Invention") disclosed in

☒ an application for United States Letters Patent entitled **TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH** ("Application");

☐ upon which United States Letters Patent, Patent Number _____ , has issued ("Patent");

Whereas, Assignor desires to convey all rights, titles, and interests in and to the same to:

PANTECH CO., LTD.
Pantech Bldg., I-2, DMC Sangam-dong
Mapo-gu
121-792 Seoul
Republic of Korea

PANTECH CO., LTD. herein further referred to as ("Assignee").

Now, for valuable consideration by Assignee to Assignor, the receipt of which is hereby acknowledged, and for other good and valuable consideration, Assignee and Assignor hereby agree as follows:

Assignor hereby conveys, assigns, sells and transfers to Assignee all rights, title and interests in and to the Invention disclosed in said application and in and to any Letters Patent of the United States (US), any continuation, division, renewal, or substitute thereof, and hereby grant to Assignee the right to apply in its own name for patents or Inventor's certificates and related rights heretofore or hereafter filed for the Invention in any and all countries, including (without limitation) all rights to claim priority based thereon, all patents granted thereon and all reissues, extensions and renewals thereof.

Assignor hereby covenants that no assignment, sale, agreement or encumbrance has been or will be made or entered into which would conflict with this Assignment.

Assignor further covenants that Assignee will, upon Assignee's request, be provided promptly with all pertinent facts and documents relating to the Invention, Patent, Application and any patents granted thereon, as may be known and accessible to Assignor, and Assignor will testify as to the same in any interference, litigation or proceeding related thereto and will promptly execute and deliver to Assignee or Assignee's legal representative any and all papers, instruments or affidavits required to apply for, protect, obtain, maintain, issue, defend and enforce the Application, Patent, Invention, whether in the US or any and all foreign countries and any patents granted thereon and/or for obtaining any reissue or reissues of any patent

which may be granted for the invention and perform such further acts which may be necessary or desirable to carry out the intent of this agreement as the Assignee thereof shall hereafter require and prepare at assignee's expense.

IN WITNESS WHEREOF, Assignor has hereunto set hand and seal.

First Inventor's Name:	Kyoungmin PARK
Address:	Pantech Bldg., I-2, DMC Sangam-dong Mapo-gu 121-792 Seoul Republic of Korea
First Inventor's Signature:	
Date:	December 28, 2012

PTO/SB/01A (07-07)
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	**TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH**

As the below named inventor(s), I/we declare that:

This declaration is directed to:

☒ The attached application having attorney docket number P5158US00, or

☐ Application No. _____ filed on _____, which is the national stage entry of PCT/KR2011/004835, filed on July 1, 2011.

☐ As amended on _____ (if applicable);

I/we believe that I/we am/are the original and first inventor(s) of the subject matter which is claimed and for which a patent is sought;

I/we have reviewed and understand the contents of the above-identified application, including the claims, as amended by any amendment specifically referred to above;

I/we acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me/us to be material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT International filing date of the continuation-in-part application.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

All statements made herein of my/our own knowledge are true, all statements made herein on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001, and may jeopardize the validity of the application or any patent issuing thereon.

FULL NAME OF INVENTOR(S)

Inventor one: Kyoungmin PARK Date: December 28, 2012

Signature: _____ Citizen of: Republic of Korea

☐	Additional inventors or a legal representative are being name on ____ additional form(s) attached hereto.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
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(71) Applicant(s):
PANTECH CO., LTD. [KR/KR]; Pantech Bldg., I-2, DMC, Sangam-dong, Mapo-gu Seoul 121-270 (KR) *(for all designated states except US)*
PARK, Kyoungmin [KR/KR]; Pantech Bldg., I-2, DMC, Sangam-dong, Mapo-gu Seoul 121-270 (KR) *(for US only)*

(72) Inventor(s):
PARK, Kyoungmin; Pantech Bldg., I-2, DMC, Sangam-dong, Mapo-gu Seoul 121-270 (KR)

(74) Agent(s):
KIM, Eungu; 2F, Sangwon Bld., 636-15 Yeoksam-dong, Gangnam-gu Seoul 135-908 (KR)

(54) Title (EN): TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

(54) Title (FR): DISPOSITIF D'ÉMISSION ET PROCÉDÉ PERMETTANT LA COMMUNICATION AVEC CE DISPOSITIF, ET DISPOSITIF DE RÉCEPTION ET PROCÉDÉ PERMETTANT LA COMMUNICATION AVEC CE DISPOSITIF

(54) Title (KO): 송신장치 및 그 통신방법, 수신장치, 그 통신방법

(57) Abstract:

(EN): An embodiment of the present invention relates to a wireless communication system, and more specifically relates to a wireless communication system using multi-input and multi-output (MIMO) antennas in all transmission and reception terminals.

(FR): Un mode de réalisation de la présente invention a trait à un système de communication sans fil, et plus particulièrement à un système de communication sans fil utilisant des antennes à entrée multiple sortie multiple (MIMO) dans tous ses terminaux d'émission et de réception.

(KO): 이 출원은 송수신단 모두에서 다중입력다중출력 (MIM0) 안테나를 이용하는 무선통신시스템에 관한 것이다. 특히, 제 1프리코더와제 2프리코더를 포함하는 송신장치에서 자신의 코드북에서 각 레이어에 대해 상기 제 1프리코더의 제 1프리코딩 행렬로사용되는 것을 제한하는 제 1정보와 상기 제 2프리 코더의 제 2프리코딩 행렬로 사용되는 것을 제한하는 제 2정보를 각각 결정하는 단계 및 결정한 상기 제 1정보와상기 제 2정보 중 적어도 하나를 포함하는 코드북제한정보를 수신장치에 전송하는 단계를 기술적 특징으로 포함하고 있다.

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AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, 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, IS, JP, KE, KG, KM, KN, KP, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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

European Patent Office (EPO) : 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

African Intellectual Property Organization (OAPI) : BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG

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Eurasian Patent Organization (EAPO) : AM, AZ, BY, KG, KZ, MD, RU, TJ, TM

(12) 특허협력조약에 의하여 공개된 국제출원

(19) 세계지식재산권기구
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(25) 출원언어: 한국어

(26) 공개언어: 한국어

(30) 우선권정보:
10-2010-0064573 2010 년 7 월 5 일 (05.07.2010) KR

(71) 출원인 (US 을(를) 제외한 모든 지정국에 대하여): **(주)팬택 (PANTECH CO., LTD.)** [KR/KR]; 서울시 마포구 상암동 DMC, I-2, 팬택빌딩, 121-270 Seoul (KR).

(72) 발명자; 겸
(75) 발명자/출원인 (US 에 한하여): **박경민 (PARK, Kyoungmin)** [KR/KR]; 서울시 마포구 상암동 DMC, I-2, 팬택빌딩, 121-270 Seoul (KR).

(74) 대리인: **김은구 (KIM, Eungu)** 등; 서울특별시 강남구 역삼동 636-15 상원빌딩 2 층, 135-908 Seoul (KR).

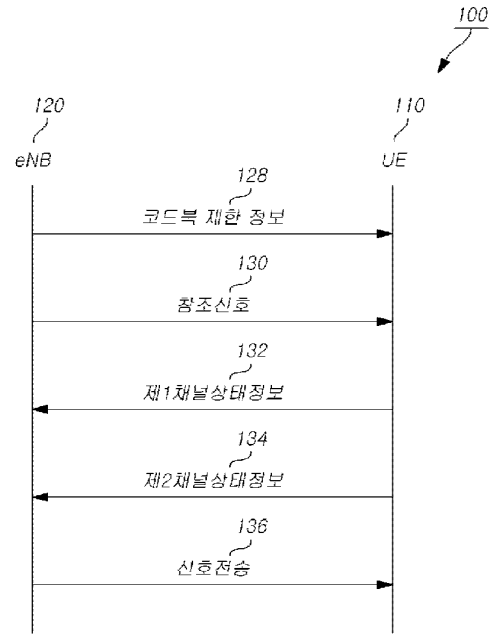
(81) 지정국 (별도의 표시가 없는 한, 가능한 모든 종류의 국내 권리의 보호를 위하여): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG,

[다음 쪽 계속]

(54) **Title**: TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

(54) **발명의 명칭** : 송신장치 및 그 통신방법, 수신장치, 그 통신방법

[Fig. 3]



120 ... eNB
110 ... UE
128 ... Codebook restriction information
130 ... Reference signal
132 ... 1st Channel status information
134 ... 2nd Channel status information
136 ... Signal transmission

(57) **Abstract**: An embodiment of the present invention relates to a wireless communication system, and more specifically relates to a wireless communication system using multi-input and multi-output (MIMO) antennas in all transmission and reception terminals.

(57) **요약서**: 이 출원은 송수신단 모두에서 다중입력다중출력 (MIM0) 안테나를 이용하는 무선통신시스템에 관한 것이다. 특히, 제 1 프리코더와제 2 프리코더를 포함하는 송신장치에서 자신의 코드북에서 각 레이어에 대해 상기 제 1 프리코더의 제 1 프리코딩 행렬로사용되는 것을 제한하는 제 1 정보와 상기 제 2 프리 코더의 제 2 프리코딩 행렬로 사용되는 것을 제한하는 제 2 정보를 각각 결정하는 단계 및 결정한 상기 제 1 정보와상기 제 2 정보 중 적어도 하나를 포함하는 코드북 제한정보를 수신장치에 전송하는 단계를 기술적 특징으로 포함하고 있다.

WO 2012/005476 A3

SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **지정국** (별도의 표시가 없는 한, 가능한 모든 종류의 역내 권리의 보호를 위하여): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), 유라시아 (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), 유럽 (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, ML, MR, NE, SN, TD, TG).

공개:

— 국제조사보고서와 함께 (조약 제 21 조(3))

— 청구범위 보정 기한 만료 전의 공개이며, 보정서를 접수하는 경우 그에 관하여 별도 공개함 (규칙 48.2(h))

(88) **국제조사보고서 공개일**: 2012 년 3 월 1 일

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2011/004835

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 7/04; H04L 27/28; H04B 15/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

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

eKOMPASS (KIPO internal) & Keywords: code book, restriction, precoder, wireless communication

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010-0048233 A1 (KIM, YU-SEOK et al.) 25 February 2010 See abstract, paragraph [50] - paragraph [52] and figure 6.	1-31
A	WO 2009-125956 A1 (LG ELECTRONICS INC. et al.) 15 October 2009 See abstract and claim 1.	1-31
PX PA	US 2011-0116563 A1 (VITTHALADEVUNI PAVAN KUMAR et al.) 19 May 2011 See abstract, paragraph [78] - paragraph [79] and figures 19,20.	1,10,18,25 2-9,11-17,19-24 ,26-31

☐ 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	Date of mailing of the international search report
28 DECEMBER2011 (28.12.2011)	**28 DECEMBER2011 (28.12.2011)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

Patent document cited in search report	Publication date	Patent family member	Publication date
US 2010-0048233 A1	25.02.2010	KR 10-2010-0023529 A	04.03.2010
WO 2009-125956 A1	15.10.2009	CN 101981823 A	23.02.2011
		CN 101981824 A	23.02.2011
		CN 101981825 A	23.02.2011
		EP 2245758 A1	03.11.2010
		EP 2248277 A1	10.11.2010
		EP 2248278 A1	10.11.2010
		EP 2340620 A2	06.07.2011
		JP 2011-517524 A	09.06.2011
		JP 2011-518491 A	23.06.2011
		JP 2011-518492 A	23.06.2011
		KR 10-2009-0106975 A	12.10.2009
		KR 10-2010-0048845 A	11.05.2010
		US 2009-0257383 A1	15.10.2009
		US 2009-0257384 A1	15.10.2009
		US 2009-0268698 A1	29.10.2009
		US 2010-0118997 A1	13.05.2010
		US 8045528 B2	25.10.2011
		WO 2009-125954 A1	15.10.2009
		WO 2009-125955 A1	15.10.2009
		WO 2010-050689 A2	06.05.2010
US 2011-0116563 A1	19.05.2011	WO 2011-060299 A2	19.05.2011
		WO 2011-060299 A3	25.08.2011

국 제 조 사 보 고 서

국제출원번호
PCT/KR2011/004835

A. 발명이 속하는 기술분류(국제특허분류(IPC))

H04B 7/04(2006.01)i

B. 조사된 분야

조사된 최소문헌(국제특허분류를 기재)
H04B 7/04; H04L 27/28; H04B 15/00

조사된 기술분야에 속하는 최소문헌 이외의 문헌
한국등록실용신안공보 및 한국공개실용신안공보: 조사된 최소문헌란에 기재된 IPC
일본등록실용신안공보 및 일본공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

국제조사에 이용된 전산 데이터베이스(데이터베이스의 명칭 및 검색어(해당하는 경우))
eKOMPASS(특허청 내부 검색시스템) & 키워드: 코드북, 제한, 프리코더, 무선통신

C. 관련 문헌

카테고리*	인용문헌명 및 관련 구절(해당하는 경우)의 기재	관련 청구항
A	US 2010-0048233 A1 (KIM YU-SEOK 외 4명) 2010.02.25 요약, 문단 [50] - 문단 [52] 및 도 6 참조.	1-31
A	WO 2009-125956 A1 (LG ELECTRONICS INC. 외 6명) 2009.10.15 요약 및 청구항 1항 참조.	1-31
PX PA	US 2011-0116563 A1 (VITTHALADEVUNI PAVAN KUMAR 외 2명) 2011.05.19 요약, 문단 [78] - 문단 [79] 및 도 19,20 참조.	1,10,18,25 2-9,11-17,19-24 ,26-31

☐ 추가 문헌이 C(계속)에 기재되어 있습니다.

☒ 대응특허에 관한 별지를 참조하십시오.

* 인용된 문헌의 특별 카테고리:

"A" 특별히 관련이 없는 것으로 보이는 일반적인 기술수준을 정의한 문헌

"E" 국제출원일보다 빠른 출원일 또는 우선일을 가지나 국제출원일 이후에 공개된 선출원 또는 특허 문헌

"L" 우선권 주장에 의문을 제기하는 문헌 또는 다른 인용문헌의 공개일 또는 다른 특별한 이유(이유를 명시)를 밝히기 위하여 인용된 문헌

"O" 구두 개시, 사용, 전시 또는 기타 수단을 언급하고 있는 문헌

"P" 우선일 이후에 공개되었으나 국제출원일 이전에 공개된 문헌

"T" 국제출원일 또는 우선일 후에 공개된 문헌으로, 출원과 상충하지 않으며 발명의 기초가 되는 원리나 이론을 이해하기 위해 인용된 문헌

"X" 특별한 관련이 있는 문헌. 해당 문헌 하나만으로 청구된 발명의 신규성 또는 진보성이 없는 것으로 본다.

"Y" 특별한 관련이 있는 문헌. 해당 문헌이 하나 이상의 다른 문헌과 조합하는 경우로 그 조합이 당업자에게 자명한 경우 청구된 발명은 진보성이 없는 것으로 본다.

"&" 동일한 대응특허문헌에 속하는 문헌

국제조사의 실제 완료일	국제조사보고서 발송일
2011년 12월 28일 (28.12.2011)	**2011년 12월 28일 (28.12.2011)**

ISA/KR의 명칭 및 우편주소
대한민국 특허청
(302-701) 대전광역시 서구 청사로 189,
정부대전청사
팩스 번호 82-42-472-7140

심사관
김병성
전화번호 82-42-481-5652

서식 PCT/ISA/210 (두 번째 용지) (2009년 7월)

국 제 조 사 보 고 서
대응특허에 관한 정보

국제출원번호
PCT/KR2011/004835

국제조사보고서에서 인용된 특허문헌	공개일	대응특허문헌	공개일
US 2010-0048233 A1	2010.02.25	KR 10-2010-0023529 A	2010.03.04
WO 2009-125956 A1	2009.10.15	CN 101981823 A	2011.02.23
		CN 101981824 A	2011.02.23
		CN 101981825 A	2011.02.23
		EP 2245758 A1	2010.11.03
		EP 2248277 A1	2010.11.10
		EP 2248278 A1	2010.11.10
		EP 2340620 A2	2011.07.06
		JP 2011-517524 A	2011.06.09
		JP 2011-518491 A	2011.06.23
		JP 2011-518492 A	2011.06.23
		KR 10-2009-0106975 A	2009.10.12
		KR 10-2010-0048845 A	2010.05.11
		US 2009-0257383 A1	2009.10.15
		US 2009-0257384 A1	2009.10.15
		US 2009-0268698 A1	2009.10.29
		US 2010-0118997 A1	2010.05.13
		US 8045528 B2	2011.10.25
		WO 2009-125954 A1	2009.10.15
		WO 2009-125955 A1	2009.10.15
		WO 2010-050689 A2	2010.05.06
US 2011-0116563 A1	2011.05.19	WO 2011-060299 A2	2011.05.19
		WO 2011-060299 A3	2011.08.25

(12) 특허협력조약에 의하여 공개된 국제출원

(19) 세계지식재산권기구
국제사무국

(43) 국제공개일
2012 년 1 월 12 일 (12.01.2012)

PCT

(10) 국제공개번호
WO 2012/005476 A2

(51) 국제특허분류:
H04B 7/04 (2006.01)

(21) 국제출원번호: PCT/KR2011/004835

(22) 국제출원일: 2011 년 7 월 1 일 (01.07.2011)

(25) 출원언어: 한국어

(26) 공개언어: 한국어

(30) 우선권정보:
10-2010-0064573 2010 년 7 월 5 일 (05.07.2010) KR

(71) 출원인 (US 을(를) 제외한 모든 지정국에 대하여): **(주)팬택 (PANTECH CO., LTD.)** [KR/KR]; 서울시 마포구 상암동 DMC, I-2, 팬택빌딩, 121-270 Seoul (KR).

(72) 발명자; 겸
(75) 발명자/출원인 (US 에 한하여): **박경민 (PARK, Kyoungmin)** [KR/KR]; 서울시 마포구 상암동 DMC, I-2, 팬택빌딩, 121-270 Seoul (KR).

(74) 대리인: **김은구 (KIM, Eungu)** 등; 서울특별시 강남구 역삼동 636-15 상원빌딩 2 층, 135-908 Seoul (KR).

(81) 지정국 (별도의 표시가 없는 한, 가능한 모든 종류의 국내 권리의 보호를 위하여): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, 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, IS, JP, KE, KG, KM, KN, KP, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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.

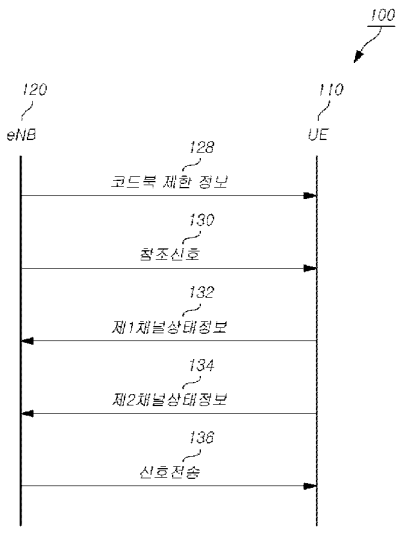
(84) 지정국 (별도의 표시가 없는 한, 가능한 모든 종류의 역내 권리의 보호를 위하여): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), 유라시아 (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), 유럽 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE,

[다음 쪽 계속]

(54) **Title**: TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

(54) **발명의 명칭** : 송신장치 및 그 통신방법, 수신장치, 그 통신방법

[Fig. 3]



120 ... eNB
110 ... UE
128 ... Codebook restriction information
130 ... Reference signal
132 ... 1st Channel status information
134 ... 2nd Channel status information
136 ... Signal transmission

(57) **Abstract**: An embodiment of the present invention relates to a wireless communication system, and more specifically relates to a wireless communication system using multi-input and multi-output (MIMO) antennas in all transmission and reception terminals.

(57) **요약서**: 본 발명의 실시예는 무선통신시스템에 관한 것으로서, 송수신단 모두에서 다중입력 다중출력 안테나(MIMO)를 이용하는 무선통신시스템에 관련된 것이다.

WO 2012/005476 A2

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, ML, MR, NE, SN, TD, TG).

공개:

— 국제조사보고서 없이 공개하며 보고서 접수 후 이를 별도 공개함 (규칙 48.2(g))

명세서

발명의 명칭: 송신장치 및 그 통신방법, 수신장치, 그 통신방법

기술분야

[1] 본 명세서는 무선통신시스템에 관한 것으로서, 송수신단 모두에서 다중입력 다중출력 안테나(MIMO)를 이용하는 무선통신시스템에 관련된 것이다.

배경기술

[2] 통신 시스템이 발전해나감에 따라 사업체들 및 개인들과 같은 소비자들은 매우 다양한 무선 단말기들을 사용하게 되었다.

[3] 현재의 3GPP, LTE(Long Term Evolution), LTE-A(LTE Advanced)등의 무선통신시스템은 음성 위주의 서비스를 벗어나 영상, 무선 데이터 등의 다양한 데이터를 송수신 할 수 있는 고속 대용량의 통신 시스템으로서, 유선 통신 네트워크에 준하는 대용량 데이터를 전송할 수 있는 기술 개발이 요구되고 있을 뿐 아니라, 정보 손실의 감소를 최소화하고, 시스템 전송 효율을 높임으로써 시스템 성능을 향상시킬 필요가 있었다.

발명의 상세한 설명

과제 해결 수단

[4] 일 실시예는, 제1프리코더와 제2프리코더를 포함하는 송신장치에서, 자신의 코드북에서 각 레이어에 대해 상기 제1프리코더의 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코더의 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 각각 결정하는 단계; 및 결정한 상기 제1정보와 상기 제2정보 중 적어도 하나를 포함하는 코드북제한정보를 수신장치에 전송하는 단계를 포함하는 송신장치의 통신방법을 제공할 수 있다.

[5] 다른 실시예는, 코드워드를 레이어에 매핑하는 레이어 맵퍼; 상기 코드워드가 상기 레이어 맵퍼에 의해 상기 레이어에 매핑된 데이터심볼을 자신의 코드북에서 선택한 제1프리코딩 행렬과 제2프리코딩 행렬을 이용하여 프리코딩하는 제1프리코더와 제2프리코더를 포함하는 프리코더; 프리코더로부터 출력된 신호들을 전송하는 안테나 어레이를 포함하며, 상기 코드워드는, 상기 코드북에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하는 송신장치를 제공할 수 있다.

[6] 다른 실시예는, 무선통신시스템에서, 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하는 코드북제한정보를 수신하는 수신단계; 및 상기 코드북제한정보를 이용하여 코드북에서 상기 제1프리코딩 행렬 또는 상기 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와

제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송하는 전송단계를 포함하는 수신장치의 통신방법을 제공할 수 있다.

[7] 다른 실시예는, 무선통신시스템에서, 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제1정보 중 적어도 하나를 코드북제한정보로 수신하는 안테나 어레이; 및 상기 코드북제한정보를 이용하여 코드북에서 상기 제1프리코딩 행렬 또는 상기 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송하는 채널정보 피드백장치를 포함하는 수신장치를 제공할 수 있다.

도면의 간단한 설명

[8] 도 1은 실시예들이 적용되는 무선 통신 시스템을 개략적으로 나타낸 도면이다.

[9] 도 2는 코드북제한시 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 무선통신시스템을 도시하고 있다.

[10] 도 3은 도 2의 코드북제한정보와 채널상태정보를 교환하는 무선통신시스템에서 참조신호와 신호 전송을 추가로 표시한 흐름도이다.

[11] 도 4는 MIMO 무선통신시스템에서 일실시예에 따른 기지국과 단말 각각의 구성도이다.

[12] 도 5는 도 4의 편파 안테나 어레이를 사용하는 기지국과 단말 사이 채널을 도시하고 있다.

[13] 도 6은 또다른 실시예에 따른 송신장치의 통신방법의 흐름도이다.

[14] 도 7은 또다른 실시예에 따른 수신장치의 통신방법의 흐름도이다.

발명의 실시를 위한 형태

[15] 이하, 본 발명의 일부 실시예들을 예시적인 도면을 통해 상세하게 설명한다. 각 도면의 구성요소들에 참조부호를 부가함에 있어서, 동일한 구성요소들에 대해서는 비록 다른 도면상에 표시되더라도 가능한 한 동일한 부호를 가지도록 하고 있음에 유의해야 한다. 또한, 본 발명을 설명함에 있어, 관련된 공지 구성 또는 기능에 대한 구체적인 설명이 본 발명의 요지를 흐릴 수 있다고 판단되는 경우에는 그 상세한 설명은 생략한다.

[16] 도 1은 실시예들이 적용되는 무선통신시스템을 도시한다.

[17] 무선통신시스템은 음성, 패킷 데이터 등과 같은 다양한 통신 서비스를 제공하기 위해 널리 배치된다.

[18] 도 1을 참조하면, 무선통신시스템은 단말(10; User Equipment, UE) 및 기지국(20; Base Station, BS)을 포함한다.

[19] 본 명세서에서의 단말(10)은 무선 통신에서의 사용자 단말을 의미하는 포괄적 개념으로서, WCDMA 및 LTE, HSPA 등에서의 UE(User Equipment)는 물론, GSM에서의 MS(Mobile Station), UT(User Terminal), SS(Subscriber Station),

무선기기(wireless device) 등을 모두 포함하는 개념으로 해석되어야 할 것이다.

[20] 기지국(20) 또는 셀(cell)은 일반적으로 단말(10)과 통신하는 지점(station)을 말하며, 노드-B(Node-B), eNB(evolved Node-B), BTS(Base Transceiver System), 액세스 포인트(Access Point), 릴레이 노드(Relay Node) 등 다른 용어로 불릴 수 있다

[21] 본 명세서에서 단말(10)과 기지국(20)은 본 명세서에서 기술되는 기술 또는 기술적 사상을 구현하는데 사용되는 두가지 송수신 주체로 포괄적인 의미로 사용되며 특정하게 지칭되는 용어 또는 단어에 의해 한정되지 않는다.

[22] 일실시예는 GSM, WCDMA, HSPA를 거쳐 LTE(Long Term Evolution) 및 LTE-advanced로 진화하는 비동기 무선통신과, CDMA, CDMA-2000 및 UMB로 진화하는 동기식 무선 통신 등에 적용될 수 있다. 본 발명은 특정한 무선통신 분야에 한정되거나 제한되어 해석되어서는 아니되며, 본 발명의 사상이 적용될 수 있는 모든 기술분야를 포함하는 것으로 해석되어야 할 것이다.

[23] 실시예들이 적용되는 무선통신시스템은 상향링크 및/또는 하향링크 HARQ(Hybrid Automatic Repeat request)를 지원할 수 있으며, 링크 적응(link adaptation)을 위해 CQI(channel quality indicator)를 사용할 수 있다. 또한, 하향링크와 상향링크 전송을 위한 다중 접속 방식은 서로 다를 수 있으며, 예컨데, 하향링크는 OFDMA(Orthogonal Frequency Division Multiple Access)를 사용하고, 상향링크는 SC-FDMA(Single Carrier-Frequency Division Multiple Access)를 사용할 수 있다.

[24] 무선통신시스템은 사용자에게 고속 정보 전송을 지원하기 위해서 다중 안테나를 포함하는 안테나 어레이를 사용하여 동일 대역을 통해 정보를 전달하는 다중 입력 다중 출력(Multiple Input Multiple Output, MIMO) 기법의 사용을 고려하고 있다.

[25] 한편, 효과적인 MIMO 시스템 구현을 위해, MIMO 무선통신시스템은 전송 용량 증대를 위해 전파 채널에 대한 정보 또는 전파 채널에 적합한 프리코더 또는 프리코딩 행렬(이하 프리코딩 행렬이라 함)에 대한 정보를 전송장치에 제공하여야 한다. 이때 전자는 큰 피드백 오버헤드를 요구하는 반면, 후자는 상대적으로 적은 피드백 오버헤드를 요구한다.

[26] 후자의 경우 각 단말(10)과 기지국(20)은 사용 가능한 N개의 프리코딩 행렬들을 한정하고 각 프리코딩 행렬을 표시하는 또는 인덱싱하는(에 대응하는) 인덱스 또는 인디케이터, 식별표시를 표현하는 코드북을 저장한다. 각 단말(10)은 전파 채널에 적합한 프리코딩 행렬을 선정하고, 선정한 프리코딩 행렬을 인덱싱하는 인덱스를 기지국(20)에 송신한다. 기지국(20)은 각 단말(10)로부터 프리코딩 행렬 인덱스들을 수신하고, 이들을 이용하여 MIMO 모드나 단말을 선정하거나, 프리코딩을 수행한다.

[27] 이때 사용 가능한 프리코딩 행렬들의 수가 많아 코드북의 크기가 클수록 기지국(120)의 프리코딩 성능은 증가하나 프리코딩 행렬 또는 그 인덱스를

기지국(20)에 보고하기 위한 단말(10)의 피드백 오버헤드는 증가할 수 있다. 따라서, 보다 효과적인 프리코딩을 위해 큰 크기 코드북(large size codebook)을 사용하되 코드북에서 적어도 하나의 프리코딩 행렬을 제한하는 코드북제한(codebook restriction) 또는 코드북 서브세트 제한(codebook subset restriction)을 사용할 수 있다.

[28] 코드북제한(codebook restriction)은 다양한 프리코딩 행렬들을 포함하는 코드북을 생성한 후 코드북에서 각 셀(cell) 단위 또는 사용자(User Equipment) 단위로 사용할/사용하지 않을 프리코딩 행렬을 선정하고 사용하지 않을 프리코딩 행렬에 대한 코드북제한정보(이하, "코드북제한정보"라 함)를 통해 각 셀 단위 또는 사용자 단위로 다른 코드북을 사용하는 기법이다. 이 코드북제한 기법의 사용시 무선통신시스템 전체는 큰 크기의 코드북을 가지지만 각 셀 또는 각 사용자가 사용하는 코드북은 코드북의 서브세트로 구성되어 크기가 작으면서 주어진 환경에 적합한 프리코딩 행렬만으로 구성되어 프리코딩 게인을 증가시킬 수 있다.

[29] 예를 들어 기지국(20)과 단말(10) 사이 하향링크 MIMO 전송시 최대 4개의 레이어들로 동시 전송할 수 있는 경우, 단말(10)은 자신이 수신할 수 있는 레이어의 수를 랭크 지시자(Rank Indicator, RI)를 사용하여 기지국(20)에 전달할 수 있다. 이 경우 기지국(20)과 단말(10) 사이 하향링크 MIMO 전송시 각 랭크당 16개의 프리코딩 행렬들을 지정하여 총 64개의 프리코딩 행렬들로 표 1과 같이 코드북을 구성할 수 있다.

[30] [표 1]

[31]

RI \ PMI	0	1	2	·····	15
1	a0	a1	a2	·····	a15
2	a16	a17	a18	·····	a31
3	a32	a33	a34	·····	a47
4	a48	a49	a50	·····	a63

[32] 코드북 제한시 64개의 프리코딩 행렬들 각각에 대하여 사용 여부를 결정하고 프리코딩 행렬들 각각의 사용여부를 1 비트를 이용하여 지정하는 비트맵 형식으로 코드북제한정보를 전송할 경우 총 64비트가 필요할 수 있다. 예를 들어 [001010010……010]와 같이 사용할 수 있는 프리코딩 행렬에 대해선 해당 순서에 1로 표시하고 사용하지 않을 프리코딩 행렬에 대해선 해당 순서에 0으로 표시할 수 있다.

[33] 한편, 단말(10)은 채널상태정보로 총 64개의 프리코딩 행렬들에 대응하는 64개의 인덱스들을 총 6비트를 사용하여 기지국(20)에 보고할 수 있다. 이때 총 64개의 프리코딩 행렬들 중 32개의 프리코딩 행렬들의 사용을 제한하는

코드북제한시 6비트로 구분해야 하는 정보의 수가 64에서 32로 감소하여 피드백 신호의 신뢰도를 증가시킬 수 있다. 한편, 단말(10)은 프리코딩 행렬들에 대응하는 인덱스들을 표현하는 비트수를 5비트로 줄여 채널상태정보의 피드백 오버헤드를 줄일 수도 있다.

[34] 아울러, 코드북 제한을 사용하여 셀간 간섭(Inter-cell interference)을 발생시킬 것이라 예상되는 프리코딩 행렬들의 사용을 제한하여 셀간 간섭의 발생을 사전에 방지할 수도 있다. 특히 각 단말의 위치에 기반한 빔 형성 기반 프리코딩(beam-forming like precoding)을 수행할 경우, 셀 경계(cell edge)에 위치한 단말은 심각한 셀 간 간섭을 발생시킬 수 있다. 이를 사전에 방지하기 위하여 셀 별 코드북 제한을 수행하여 셀 간 간섭을 제어할 수 있다.

[35] 기지국(20)은 적어도 두개의 프리코더들을 포함하는 다단 구조의 프리코더를 사용할 수 있다. 다단 구조의 프리코더를 사용할 경우도 각 프리코더에 사용하는 프리코딩 행렬을 제한하는 코드북제한을 사용할 수 있다. 이 경우 전체적으로 프리코딩 행렬들의 수가 증가하며 코드북제한을 위해 사용하는 코드북제한정보를 위해 사용되는 비트수도 증가할 수 있다.

[36] 특히, 상향링크 또는 하향링크에서 고속 정보 전송을 지원하기 위해 높은 시그널링과 피드백 오버헤드를 사용해야 하기 때문에, 기지국(20)이 각 단말(10)에코드북 제한을 알리기 위해 사용하는 비트수도 줄일 필요가 있다.

[37] 이상 실시예들이 적용되는 무선통신시스템을 설명하였으나 이하 도 2 및 도3을 참조하여 다단 구조의 프리코더를 사용할 경우 코드북제한시 무선통신시스템에서 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 과정을 기재한다.

[38] 도 2는 코드북제한시 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 무선통신시스템을 도시하고 있다.

[39] 도 2를 참조하면, 무선통신시스템(100)은 도 1의 무선통신시스템과 동일하게 기지국(120)과 무선통신시스템(100) 내에 존재하는 적어도 하나의 단말, 예를 들어 n개의 단말들(110)을 포함할 수 있다. 이 단말들(110)은 현재 접속되어 있거나 추가 접속을 시도하는 단말들일 수 있으나 도 2에는 하나의 단말만을 표시한다.

[40] 기지국(120)은 후술하는 바와 같이 적어도 두개의 제1및 제2프리코더들을 포함하는 다단 구조의 프리코더를 포함하고 있다. 기지국(120)은 제1프리코더에 사용되는 N개의 제1프리코딩 행렬들과 이들을 인덱싱하는 제1인덱스들을 표현하는 제1코드북(122)과 제2 프리코더에 사용되는 M개의 제2프리코딩 행렬들과 이들을 인덱싱하는 제2인덱스들을 표현하는 제2코드북(124)을 저장하고 있다.

[41] 기지국(120)은 랭크들과 랭크들 각각에 대한 제1인덱스들 각각과 제2인덱스들 각각의 쌍에 대응하는 인덱스(이하, 제한 인덱스라 함)를 포함하는 제한북(126, restriction book)을 저장하고 있다. 기지국(120)은 각 셀(cell) 단위 또는

사용자(User Equipment) 단위로 사용할/사용하지 않을 프리코딩 행렬을 결정하고 사용하지 않을 프리코딩 행렬에 대한 코드북제한정보(128)를 단말(110)에 전송할 수 있다. 이때 코드북제한정보(128)는 제1 및 제2코드북들(122, 124)에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 포함하고 있다.

[42] 도 3은 도 2의 코드북제한정보와 채널상태정보를 교환하는 무선통신시스템에서 참조신호와 신호 전송을 추가로 표시한 흐름도이다.

[43] 도 3을 참조하면, 단말(110)과 기지국(120) 사이 데이터를 송수신하기 위해 송신자 측 기지국(120)은 도 3에 추가로 도시한 바와 같이 참조신호(130)를 전송하고, 수신자 측 단말(receiver side, 110)은 이 참조신호(130)를 이용하여 채널을 추정할 수 있다. 예를 들어, 하향링크 전송시 단말(110)은 하향링크 채널을 추정할 수 있다. 특히 OFDM 전송시 단말(110)은 각 서브캐리어의 채널을 추정할 수 있다. 반대로, 상향링크 전송시 기지국(120)은 상향링크 채널을 추정할 수 있다.

[44] 채널의 추정을 위해 주파수-도메인 그리드 내에 규칙 또는 불규칙한 간격으로 특정 신호 또는 심볼을 삽입할 수 있다. 이때 이 특정 신호 또는 심볼을 참조신호(reference signal) 또는 참조심볼(reference symbol), 파일롯 심볼(pilot symbol) 등 다양하게 명명하고 본 명세서에서는 이 특정 신호 또는 심볼을 참조신호라 하나 그 용어에 제한되지 않는다. 물론 참조신호(130)는 주파수 도메인 채널의 추정에만 사용되지 않고 단말과 기지국 사이의 무선통신 과정에서 필요한 위치추정, 제어정보의 송수신, 스케줄링정보의 송수신, 피드백정보의 송수신 등을 위해서 사용될 수도 있다.

[45] 하향링크 또는 상향링크 전송시 각각 여러 종류의 참조신호들이 존재하며 다양한 용도로 새로운 참조신호들이 정의되고 있으며 논의되기도 한다. 예를 들어 상향링크 전송시 참조신호로 DM-RS(Demodulation RS), SRS(Sounding RS) 등이 있다. 하향링크 전송시 참조신호로 DM-RS(Demodulation RS), CRS(Cell-specific RS), MBSFN RS, UE-specific RS 등이 있다. 또한, 하향링크 전송시 단말(110)에서 중심 셀 또는 인접 셀들의 채널상태정보(Channel State Information(CSI))를 획득하기 위하여 기지국에서 전송하는 참조신호로 CSI-RS가 있다. 이 CSI-RS는 CQI(Channel Quality Indicator)/PMI(Precoder Matrix Indicator)/RI(Rank Indicator) 등을 리포팅하는데 사용될 수 있다. 이 CSI-RS는 CSI-RS를 전송하는 기지국에 포함된 각 셀마다 서로 구분가능하도록 셀-특화(Cell-specific)되며 낮은 오버헤드를 위해 주파수와 시간에서 충분히 산재해야 한다.

[46] 다시 도 2를 참조하면, 단말(110)은 제1프리코더에 사용되는 N개의 제1프리코딩 행렬들과 이들을 인덱싱하는 제1인덱스들을 표현하는 제1코드북(112)과 제2 프리코더에 사용되는 M개의 제2프리코딩 행렬들과 이들을 인덱싱하는 제2인덱스들을 표현하는 제2코드북(114)을 저장하고 있다.

제1코드북(112)와 제2코드북(114)는 각각 기지국(120)가 저장하고 있는 제1코드북(122)와 제2코드북(124)와 동일하다.

[47] 단말(110)은 랭크들과 랭크들 각각에 속하는 제1인덱스 및 제2인덱스 쌍에 대응한 복수의 인덱스들(이하, 제한 인덱스라 함)을 포함하는, 표 4를 참조하여 후술할, 제한북(116)을 저장하고 있다. 각 단말(110)이 저장하고 있는 제한북(116)은 기지국(120)이 저장하고 있는 제한북(126)과 동일하다.

[48] 단말(110)은 기지국(120)으로부터 전술한 코드북제한정보(128)를 수신할 수 있다. 이 코드북제한정보(128)는 제1 및 제2코드북들에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하고 있다.

[49] 단말(110)은 코드북제한정보(128)에 포함된 제1정보에 따라 제1프리코딩 행렬로 사용되는 것이 제한된 프리코딩 행렬들을 제외하고 제1프리코딩 행렬을 결정하고 그 제1프리코딩 행렬에 대한 제1채널상태정보(132)를 기지국(120)에 보고/피드백할 수 있다. 또한, 각 단말(110)은 코드북제한정보(128)에 포함된 제2정보에 따라 제2프리코딩 행렬로 사용되는 것이 제한된 프리코딩 행렬들을 제외하고 제2프리코딩 행렬을 결정하고 그 제2프리코딩 행렬에 대한 제2채널상태정보(134)를 기지국(120)에 보고/피드백할 수 있다.

[50] 기지국(120)은 각 단말(110)로부터 보고받은 채널상태정보들(132, 134)을 기초로 이용하여 제1코드북(122)와 제2코드북(124)에서 제1프리코더와 제2프리코더의 프리코딩 행렬들을 결정하고 그 프리코딩 행렬들을 이용하여 데이터심볼들을 프리코딩한다.

[51] 다시 도 3을 참조하면, 최종적으로 기지국(120)은 도 3에 추가로 도시한 바와 같이 프리코딩된 신호(136)를 단말(110)에 전송한다. 반대로 단말(110)은 이 신호(136)을 수신한 후 원 데이터를 디코딩한다.

[52] 이상 다단 구조의 프리코더를 사용할 경우 코드북제한시 무선통신시스템에서 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 과정을 설명하였으나 이하에서 코드북제한정보와 채널생태정보를 송수신하는 MIMO 무선통신시스템에 대해 상세히 기재한다.

[53] 도 4는 MIMO 무선통신시스템에서 일실시예에 따른 기지국과 단말 각각의 구성도이다. 도 5는 도 4의 편파 안테나 어레이를 사용하는 기지국과 단말 사이 채널을 도시하고 있다.

[54] 도 4을 참조하면, MIMO 무선통신시스템은 단말(410)과 기지국(420)을 포함할 수 있다.

[55] 단말(410)은 하향링크 채널을 통해 신호를 수신하는 안테나 어레이(411)와 수신한 신호를 처리하고 프리코딩 행렬을 이용하여 원래의 데이터 심볼로 디코딩하는 포스트 디코더(post-decoder, 412), 채널정보 피드백장치(414)를 포함한다.

[56] 안테나 어레이(411)는 다수의 안테나들을 사용할 수 있다. 이때 안테나

어레이(411)은 편파 안테나 어레이를 형성할 수도 있다. 무선통신시스템에서 한정된 공간에 보다 많은 안테나들을 배열하기 위해 서로 다른 편파를 가지는 두 개의 안테나들을 교차하여 설치한 이중 편파 안테나 어레이(dual polarized antenna array)를 사용하여 어레이를 구현할 수도 있다.

[57] 도 5를 참조하면, 수직방향을 기준으로 오른쪽으로 편파된 것으로 "+"로 표시하고 왼쪽으로 편파된 것을 "-"로 표시할 때 단말(410)은 수직방향을 기준으로 45도로 편파된 하나의 안테나들(411aa 내지 411ab)와 -45도로 편파된 다른 안테나(411ba 내지 411bb)가 서로 직교하는 안테나쌍 두개를 포함하는 편파 안테나 어레이(411)를 포함하고 있다. 이때 +45도로 편파된 안테나들(411aa 내지 411ab)은 송신측 제1서브세트 또는 제1도메인(411a)이라 할 수 있고 -45도로 편파된 다른 안테나들(411ba 내지 411bb)은 송신측 제2서브세트 또는 제2도메인(411b)이라고 할 수 있다.

[58] 다시 도 4를 참조하면, 포스트 디코더(412)는 기지국(420)의 제1프리코더(422)와 제2프리코더(424)에 대응된다. 포스트 디코더(412)는 수신한 참조신호를 채널정보 피드백장치(414)에 전달한다.

[59] 채널정보 피드백장치(414)는 참조신호를 수신하고 이 참조신호를 이용하여 채널을 추정할 수 있다. 채널정보 피드백장치(414)는 제1채널상태정보와 제2채널상태정보를 포함하는 채널정보를 생성할 수 있다. 채널정보 피드백장치(414)는 이 채널정보를 기지국(420)에 피드백할 수 있다.

[60] 기지국(420)은 코드워드를 레이어에 맵핑하는 레이어 맵퍼(421)와 레이어 매핑된 데이터 심볼들을 프리코딩 행렬을 이용하여 프리코딩하는 프리코더(425), 프리코딩된 신호를 공중으로(on air)으로 전송하는 안테나 어레이(428)를 포함한다. 프리코더(425)는 데이터 심볼들을 프리코딩하는 제1프리코더(422)와 제2프리코더(424)를 포함할 수 있다. 이때 제1프리코더(422)과 제2프리코더(424)는 각각 자신의 제1프리코딩 행렬과 제2프리코딩 행렬에 의해 데이터 심볼들을 프리코딩할 수 있다.

[61] 기지국(420)의 안테나 어레이(428)는 다수의 안테나들을 사용할 수 있다. 이때 안테나 어레이(428)은 편파 안테나 어레이를 형성할 수도 있다. 무선통신시스템에서 한정된 공간에 보다 많은 안테나들을 배열하기 위해 서로 다른 편파를 가지는 두 개의 안테나들을 교차하여 설치한 이중 편파 안테나 어레이(dual polarized antenna array)를 사용하여 어레이를 구현할 수도 있다. 이때 안테나 어레이들(411, 428)이 이중 편파 안테나 어레이를 사용하는 것을 예시적으로 설명하였으나 이에 제한되지 않는다.

[62] 도 5를 참조하면, 기지국(420)은 수직방향을 기준으로 45도로 편파된 하나의 안테나(428aa 내지 428ad)와 -45도로 편파된 다른 안테나들(428ba 내지 428bd)가 서로 직교하는 안테나쌍 네개를 포함하는 편파 안테나 어레이(428)를 포함하고 있다. 이때 +45도로 편파된 안테나들(428aa 내지 428ad)을 수신측 제1서브세트 또는 제1도메인(428a)이라 하고 -45도로 편파된 다른 안테나들(428ba 내지

428bd)을 수신측 제2서브세트 또는 제2도메인(428b)이라고 할 수 있다.

[63] 단말(410)과 기지국(420) 각각의 편파 안테나들 사이에 위상 불일치(phase mismatch)가 없는 경우 전체 채널 H는 수학식 1과 같이 표현할 수 있다.

[64] [수학식 1]

[65]

$$H = \begin{bmatrix} H_h & 0 \\ 0 & H_v \end{bmatrix}$$

[66] 이때 H_h는 단말(410)의 제1서브세트 또는 제1도메인(411a)과 기지국(420)의 제1서브세트 또는 제1도메인(428a) 사이의 채널을 의미하고 H_v는 제2서브세트 또는 제2도메인(411b)과 기지국(420)의 제2서브세트 또는 제2도메인(428b) 사이의 채널을 의미한다.

[67] 수학식 1을 통해 알 수 있는 바와 같이 서로 다른 방향으로 편파된 안테나들은 서로 직교하면서 위상 불일치가 없는 경우 서로 영향을 주지 않는다. 따라서, H_h와 H_v만을 추정하므로 채널을 알 수 있다. 인접하는 편파 안테나들 사이 거리(d)가 신호 파장(λ)에 비해 작으면 안테나 사이 상관성(correlation)이 클 수 있다. 이때 H_h와 H_v는 안테나 간 거리(d)와 단말(410)에 도달하는 신호 전파의 입사각(θ)에 의해 결정될 수 있다.

[68] 단말(410)과 기지국(420) 각각의 편파 안테나들 사이에 위상 불일치(phase mismatch)가 존재하는 경우, 예를 들어 단말(410)의 안테나 쌍들이 왼쪽으로 ε 만큼 틀어진 경우 기지국(420)의 각 편파 도메인에서 전송된 신호들이 단말(410)의 두 개의 편파 도메인들에 모두 수신됨으로 도메인 간 위상차에 따라 도메인간 간섭이 발생할 수 있다. 따라서, 채널은 단말(410)과 기지국(420) 각각의 편파 안테나들 사이에 위상 오차 또는 불일치(phase mismatch)의 정도, 즉 ε 에 의하여 영향을 받게 되어 전체 채널 H는 수학식 2와 같이 표현할 수 있다.

[69] [수학식 2]

[70]

$$H = \begin{bmatrix} H_h \cos\varepsilon & -H_v \sin\varepsilon \\ H_h \sin\varepsilon & H_v \cos\varepsilon \end{bmatrix}$$

[71] 다시 도4를 참조하면, 제2프리코더(424)는 수평방향과 수직방향으로 교차된 안테나 어레이(428)에 의해 형성하는 편파 도메인(polarized domain) 간 위상 오차 또는 불일치(phase mismatch)의 영향을 제거하기 위해 위상차를 보정하며 제1프리코더(422)는 도메인 간 프리코딩을 수행할 수 있다.

[72] 한편, 동일한 위치에 각 두 개의 안테나를 배치하는 방식으로 이중 편파 도메인이 구성됨으로, 각 편파 도메인은 동일한 공간적 채널 특성을 가질 수 있다. 즉, 각 도메인은 동일한 프리코딩 행렬($H_h=H_v=R_0$)을 사용하여 프리코딩되며, 각 편파 도메인을 통해 전송된 신호는 위상 및 크기 차이를 가지고 단말(410)에 도달할 수 있다. 이때 제1프리코더(422)와 제2프리코더(424)에서 사용하는 제1프리코딩 행렬과 제2프리코딩 행렬을 수식으로 표현하면 아래 수학식 3과 같을 수 있다.

[73] [수학식 3]

[74]

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

[75] 상기 수학식3에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한 공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 Λ는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

[76] 각 도메인에 수신된 신호의 크기는 제1프리코딩 행렬 W_1의 R_0의 프리코딩 게인에 의해 결정되며, 제2프리코딩 행렬 W_2은 각 도메인에 수신된 신호 간 위상차를 보정한다. 상기 방식으로 동작 시, 제1프리코딩 행렬 W_1을 설정을 위한 제1인덱스(PMI_1) 선정과 제2프리코딩 행렬 W_2을 설정을 위한 제2인덱스(PMI_2)의 선정은 독립적으로 수행될 수 있다.

[77] 수학식 3을 통해 알 수 있는 바와 같이 프리코더(425)는 두 개의 도메인 (편파 도메인 또는 안테나들의 서브세트) 내에서 각각 프리코딩 게인에 의해 결정되는 R_0을 사용하여 프리코딩을 수행하는 제1프리코딩 행렬과, 도메인간 위상차 보정(co-phaing) 작업을 수행하는 제 2 프리코딩 행렬로 구성된 프리코더이다. 따라서, 두 개의 독립된 도메인 각각은 프리코딩 게인에 의해 결정되는 R_0을 통해 프리코딩되며 그 중 하나의 도메인은 Λ에 의해 위상 보정된 후 전송된다.

[78] 프리코더(425)에서, 제2프리코딩 행렬은 편파 안테나에서 각 편파 도메인간위상오차에 의한 신호감쇠를 보정하는 프리코딩 행렬이다. 또한, 제2프리코딩 행렬은 편파 도메인 간 위상오차에 의한 신호감쇠를 보상하는 프리코딩 행렬일 수도 있고, 편파 안테나간 자연스럽게 발생하게 되는 위상차이를 보정하기 위한 프리코딩 행렬일 수도 있다. 기지국(420)은

제1프리코더(422)에 사용되는 N개(N은 1 이상의 자연수)의 제1프리코딩 행렬들과 이들을 인덱싱하는 제1인덱스들을 표현하는 제1코드북과 제2 프리코더(424)에 사용되는 M개(M은 1 이상의 자연수)의 제2프리코딩 행렬들과 이들을 인덱싱하는 제2인덱스들을 표현하는 제2코드북을 저장하고 있다.

[79] 표 2와 표 3은 안테나 어레이(428)이 8개의 이중 편파 안테나들(428a, 428b)을 포함하여 총 8개의 레이어들을 동시 전송할 때 랭크당 각각 16개와 4개의 프리코딩 행렬들을 사용하는 제1코드북과 제2코드북의 예들이다.

[80] [표 2]

[81]

RI \ PMI_1	0	1	2	.....	15
1	b0	b1	b2	.....	b15
2	b16	b17	b18	.....	b31
.....	.....	.....	.....	.....	.....
8	b112	b113	b114	.....	b127

[82] [표 3]

[83]

RI \ PMI_2	0	1	2	3
1	c0	c1	c2	c3
2	c4	c5	c6	c7
.....	.....	.....	.....	.....
8	c28	c29	c30	c31

[84] 기지국(420)은 랭크들과 랭크들 각각에 대한 제1인덱스들 각각과 제2인덱스들 각각의 쌍에 대응하는 인덱스(이하, 제한 인덱스라 함)를 포함하는 제한북을 저장하고 있다. 표 4는 안테나 어레이(428)가 8개의 이중 편파 안테나들(428a, 428b)을 포함하여 총 8개의 레이어들을 동시 전송할 때 랭크당 각각 16개 및 4개의 프리코딩 행렬들을 사용하는 제한북이다.

[85] [표 4]

[86]

RI \ (PMI_1, PMI_2)	(0.0)	(0.1)	(0.2)	(0.3)	(1.0)	(1.1)	.....	(15.1)	(15.2)	(15.3)
1	a0	a 1	a 2	a 3	a4	a5	.....	a61	a62	a63
2	a64	a65	a66	a67	a68	a69	.....	a125	a126	a127
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	a448	a449	a450	a451	a452	a453	.....	a509	a510	a511

[87] 코드북 제한시 프리코딩 행렬들 각각의 사용여부를 한비트를 이용하여 지정하는 비트맵 형식으로 코드북제한정보를 전송할 경우 랭크들과 랭크들 각각에 대한 제1인덱스들 각각과 제2인덱스들 각각의 쌍에 대해 총 16×4×8 = 512 비트들을 필요로 할 수 있다.

[88] 그런데 전술한 바와 같이 제1프리코딩 행렬(W_1)을 설정을 위한 제1인덱스(PMI_1) 선정과 제2프리코딩 행렬(W_2)을 설정을 위한 제2인덱스(PMI_2) 선정은 독립적으로 수행될 수 있으므로 각 랭크에 대해 제1프리코더와 제2프리코더별로 프리코딩 행렬들 각각에 대해 독립적으로 코드북을 제한할 수도 있다. 표 5 는 제한북에서 랭크1에 대해 제1인덱스=0(PMI_1=0) 및 제2인덱스=1(PMI_2=1)에 대하여 코드북 제한을 결정되었을 경우 제한되는 프리코더들을 표현하고 있다.

[89] [표 5]

[90]

RI \ (PMI_1, PMI_2)	(0.0)	(0.1)	(0.2)	(0.3)	(1.0)	(1.1)	.....	(15.1)	(15.2)	(15.3)
1	a0	a1	a2	a3	a4	a5	.....	a61	a62	a63
2	a64	a65	a66	a67	a68	a69	.....	a125	a126	a127
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	a448	a449	a450	a451	a452	a453	.....	a509	a510	a511

[91] 표 5에 도시하지 않았지만 8개의 랭크들에 대해서 전술한 랭크1에 대해 코드북 제한하는 방식으로 제1프리코딩 행렬과 제2프리코딩 행렬을 독립적으로 코드북 제한할 수 있다.

[92] 기지국(420)은 각 셀(cell) 단위 또는 사용자(User Equipment) 단위로 사용할/사용하지 않을 프리코딩 행렬을 결정하고 사용하지 않을 프리코딩 행렬에 대한 코드북제한정보를 단말(410)에 전송할 수 있다. 이때 코드북제한정보는 제1 및 제2코드북들에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을

제한하는 제2정보를 포함하고 있다.

[93] 표 5 과 같이 랭크1에 대해 제1인덱스=0(PMI_1=0) 및 제2인덱스=1(PMI_2=1)에 대하여 코드북 제한이 결정되었을 경우 코드북제한정보는 비트맵형식으로 제1정보인 [0111111111111111]와 제2정보인 [1011]를 포함할 수 있다. 전술한 바와 같이 사용할 수 있는 프리코딩 행렬에 대해선 해당 순서에 1로 표시하고 사용하지 않을 프리코딩 행렬에 대해선 해당 순서에 0으로 표시할 수 있다. 결과적으로 제1인덱스=0(PMI_1=0)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (**0**.1), (**0**.1), (**0**.2), (**0**.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=1(PMI_2=1)과 쌍을 이루는 제1인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.1), (1.1),….. (14.1), (15.1)도 전체적으로 코드북이 제한된다.

[94] 랭크2에 대해 제1인덱스=1(PMI_1=1) 및 제2인덱스=2(PMI_2=2)에 대하여 코드북 제한이 결정되었을 경우 코드북제한정보는 비트맵형식으로 제1정보인 [1011111111111111]와 제2정보인 [1101]를 포함할 수 있다. 결과적으로 제1인덱스=1(PMI_1=1)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (**1**.1), (**1**.1), (**1**.2), (**1**.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=2(PMI_2=2)과 쌍을 이루는 제1인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.2), (1.2),….. (14.2), (15.2)도 전체적으로 코드북이 제한된다.

[95] 랭크8에 대해 제1인덱스=0(PMI_1=0) 및 제2인덱스=3(PMI_2=3)에 대하여 코드북 제한이 결정되었을 경우 코드북제한정보는 비트맵형식으로 제1정보인 [0111111111111111]와 제2정보인 [1110]를 포함할 수 있다. 제1인덱스=0(PMI_1=0)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (**0**.1), (**0**.1), (**0**.2), (**0**.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=3(PMI_2=3)과 쌍을 이루는 제1인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.3), (1.3),….. (14.3), (15.3)도 전체적으로 코드북이 제한된다.

[96] 다시 말해, 코드북제한정보는 제1정보와 상기 제2정보를 포함하므로, 제1정보에 따라 제1프리코딩 행렬로 사용되는 것을 제한됨에 따라 사용이 제한된 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고 제2정보에 따라 제2프리코딩 행렬로 사용되는 것을 제한함에 따라 사용이 제한되는 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용을 제한할 수 있다.

[97] 랭크 3 내지 7에 대해서도 동일한 방식으로 코드북제한정보를 비트맵형식으로 제1정보와 제2정보를 포함할 수 있다. 이때 제1정보와 제2정보를 포함하는 코드북제한정보가 비트맵형식인 것으로 설명하였으나 이는 예시에 불과하며 이에 제한되지 않는다.

[98] 전술한 방법과 동일한 방식으로 랭크 1 내지 8도 동일한 비트맵형식으로 코드북제한정보를 전송하면 총 랭크 8에 대한 제1프리코딩 행렬과 제2프리코딩 행렬을 독립적으로 제한하는 코드북제한정보의 총 비트수는 (16 + 4)×8 = 160 비트들이 된다.

[99] 기지국(420)은 각 랭크에 대해 20비트씩 비트맵형식으로 랭크 1부터 랭크 8까지 총 160비트로 코드북제한을 표현한 코드북제한정보를 단말(410)에 전송할 수 있다. 이 코드북제한정보는 하향링크 제어정보, 예를 들어 RRC 신호로 물리적 하향링크 공유채널(Physical Downlink Shared Channel, PDSCH)을 통해 기지국(420)으로부터 단말(410)에 전송될 수 있다. 이때 코드북제한정보는 PDSCH 이외에 물리적 하향링크 제어채널(Physical Downlink Control Channel, PDCCH)과 같은 다른 채널을 통해 기지국(420)으로부터 단말(410)로 전송될 수도 있다. 이때 코드북제한정보는 제1정보와 제2정보를 각 랭크에 대해 순차적으로 포함할 수도 있다. 예를 들어 코드북제한정보는 랭크 1에 대한 제1정보와 제2정보, 랭크 2에 대한 제1정보와 제2정보,...랭크8에 대한 제1정보와 제2정보의 순서로 제1정보와 제2정보를 포함할 수 있다.

[100] 한편, 코드북제한정보는 각 랭크에 대한 제1정보를 순차적으로 포함하고 그후 각 랭크에 대한 제2정보를 순차적으로 포함할 수도 있다. 예를 들어, 코드북제한정보는 랭크1 내지 랭크 8에 대한 제1정보들을 순차적으로 포함하고, 그후 랭크1 내지 랭크8에 대한 제2정보들을 순차적으로 포함할 수 있다. 물론, 코드북제한정보는 각 랭크별로 제1정보와 제2정보를 독립적으로 기지국(420)으로부터 단말(410)으로 전송될 수도 있다. 물론, 특정 랭크에 대해 코드북을 제한하지 않는 경우 그 특정 코드북에 대한 코드북제한정보는 포함되지 않게 된다.

[101] 결과적으로 제1인덱스와 제2인덱스를 쌍으로 제한할 경우 코드북제한정보가 총 512비트가 필요한 것에 비하여 제1인덱스와 제2인덱스를 독립적으로 결정 및 전송할 경우 코드북제한정보의 피드백 오버헤드를 상당히 줄일 수 있다.

[102] 한편, 제1프리코더(422)가 제1프리코딩 행렬을 사용하여 도메인 간 프리코딩(Intra-domain precoding)시, 예를 들어 제1인덱스=7(PMI_1=7)으로 표기되는 프리코딩 행렬들이 도메인 간 프리코딩 게인이 적어 사용되지 않는 것으로 코드북을 제한하는 경우, 제2프리코더(424)가 제2프리코딩 행렬을 사용하여 위상차 보정시 PMI_1=7으로 표기되는 어떤 프리코딩 행렬도 우수한 프리코딩 게인을 얻을 수 없다.

[103] 즉, 도메인 간 프리코딩(Intra-domain precoding)을 수행하는 제1프리코딩 행렬에 대한 제한을 결정하는 것이 위상차 보정을 수행하는 제2프리코딩 행렬에 대한 제한을 결정하는 것보다 우선할 수도 있다. 따라서, 코드북제한시 제1프리코딩 행렬에 대해서만 제한을 설정할 수도 있다. 이때 코드북제한정보는 제1프리코딩 행렬만을 제한하는 제1정보만을 포함하므로 총 $16 \times 8 = 128$ 비트들이 필요할 수 있다.

[104] 한편, 도메인 간 간섭이 동일한 조건에서 도메인 간 위상차 간섭이 우선할 경우 제2프리코딩 행렬에 대해서만 제한을 설정할 수도 있다. 이때 코드북제한정보는 제2프리코딩 행렬만을 제한하는 제2정보만을 포함하므로 $4 \times 8 = 32$ 비트들이 필요할 수 있다.

[105] 전술한 바와 같이 제1프리코딩 행렬과 제2프리코딩 행렬을 모두 제한하되 독립적으로 제한하는 경우와, 제1프리코딩 행렬만을 제한하는 경우, 제2프리코딩 행렬만을 제한하는 경우를 선택적으로 사용할 수도 있다. 이때는 기지국(420)은 단말(410)에 제한 모드(restriction mode)를 지시하는 총 2비트의 식별표지(restriction mode indicator)를 전송할 수 있다.

[106] 한편, 단말(410)의 채널정보 피드백장치(414)는 코드북제한정보에 포함된 제1정보에 따라 제1프리코딩 행렬로 사용되는 것이 제한된 프리코딩 행렬들을 제외하고 제1프리코딩 행렬을 결정하고 그 제1프리코딩 행렬에 대한 제1채널상태정보를 기지국(420)에 보고/피드백할 수 있다. 전술한 예에서 랭크1에 대해 제1인덱스=0(PMI_1=0)에 대하여 코드북을 제한하는 비트맵형식의 제1정보인 [0111111111111111]를 수신한 경우, 채널정보 피드백장치(414)는 표 5와 같이 제1인덱스=0(PMI_1=0)를 제외한 인덱스들, 즉 제1인덱스=0에 해당하는 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 제1프리코딩 행렬을 결정하고 그에 대한 제1채널상태정보를 기지국에 보고/피드백할 수 있다. 또한, 각 단말(410)은 코드북제한정보에 포함된 제2정보에 따라 제2프리코딩 행렬로 사용되는 것이 제한된 프리코딩 행렬들을 제외하고 제2프리코딩 행렬을 결정하고 그 제2프리코딩 행렬에 대한 제2채널상태정보를 기지국(420)에 보고/피드백할 수 있다. 전술한 예에서 랭크1에 대해 제2인덱스=1(PMI_2=1)에 대하여 코드북을 제한하는 비트맵형식의 제2정보인 [1011]를 수신한 경우, 채널정보 피드백장치(414)는 표 5와 같이 제2인덱스=1(PMI_2=1)를 제외한 인덱스들, 즉 제2인덱스=1에 해당하는 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 제2프리코딩 행렬을 결정하고 그에 대한 제2채널상태정보를 기지국에 보고/피드백할 수 있다.

[107] 랭크2에 대해 제1인덱스=1(PMI_1=1) 및 제2인덱스=2(PMI_2=2)에 대하여 코드북을 제한하는 비트맵형식의 제1정보인 [1011111111111111]와 제2정보인 [1101]를 수신한 경우 채널정보 피드백장치(414)는 표 5와 같이 랭크2에 대해 제1인덱스=1(PMI_1=1) 및 제2인덱스=2(PMI_2=2)를 제외한 제1프리코딩 행렬과 제2프리코딩 행렬을 결정하고 그에 대한 제1채널상태정보와 제2채널상태정보를 기지국에 보고/피드백할 수 있다. 랭크 3 내지 랭크 8도 동일한 방식으로 채널정보 피드백장치(414)는 제1정보와 제2정보에서 지정한 프리코딩 행렬들을 제외하고 제1프리코딩 행렬과 제2프리코딩 행렬을 결정할 수 있다.

[108] 전술한 바와 같이 제1프리코딩 행렬과 제2프리코딩 행렬을 모두 제한하되 독립적으로 제한하는 경우와, 제1프리코딩 행렬만을 제한하는 경우, 제2프리코딩 행렬만을 제한하는 경우를 선택적으로 사용하고 기지국(420)은 단말(410)에 제한 모드를 지시하는 총 2비트의 식별표지(restriction mode indicator)를 전송할 경우 단말(410)의 채널정보 피드백장치(414)는 그 제한 모드에 맞추어 제1프리코딩 행렬과 제2프리코딩 행렬을 결정하고

제1채널상태정보와 제2채널상태정보를 생성 및 보고할 수 있다.

[109] 제1채널상태정보와 제2채널상태정보의 피드백 주기 또는 간격이 다를 수 있다. 예를 들어 제1채널상태정보는 숏텀으로 기지국(420)에 피드백되고 제2채널정보는 롱텀으로 기지국(420)에 피드백될 수 있다. 다시 말해, 긴 주기/롱텀과 짧은 주기/숏텀은 서로 상대적인 의미로, 긴 주기/롱텀은 짧은 주기/숏텀보다 긴 주기를 의미한다.

[110] 기지국(420)의 제1프리코더(422)과 제2프리코더(424)는 각 단말(410)로부터 보고받은 채널상태정보들을 기초로/이용하여 제1및 제2 프리코딩 행렬들을 결정하고 그 프리코딩 행렬들을 이용하여 데이터심볼들을 프리코딩한다.

[111] 이상, 또다른 실시예에 따라 코드북제한정보와 채널생태정보를 송수신하는 MIMO 무선통신신스템에 대해 기재하였으나, 이하 또다른 실시예에 따른 송신장치의 통신방법에 대해 기재한다.

[112] 도 6은 또다른 실시예에 따른 송신장치의 통신방법의 흐름도이다.

[113] 도 6을 참조하면, 또다른 실시예에 따른 송신장치의 통신방법(600)는 코드워드를 레이어에 맵핑하는 레이어 맵핑 단계(S610)과 심볼들을 프리코딩하는 프리코딩 단계(S620), 둘 이상의 안테나들을 통해 프리코딩된 심볼을 공중으로 전파하는 전송단계(S630)을 포함할 수 있다. 레이어 맵핑 단계(S610)와 프리코딩 단계(S620), 전송단계(S630)는 전술한 바와 동일하므로 구체적인 설명을 생략한다.

[114] 또다른 실시예에 따른 기지국의 통신방법(600)은 표 5를 참조하여 각 랭크에 대해 표 3의 제1프리코딩 행렬과 표 4의 제2프리코딩 행렬을 독립적으로 코드북 제한하여 각 랭크에 대해 20비트씩 비트맵형식으로 랭크 1부터 랭크 8까지 총 160비트로 코드북제한을 표현한 코드북제한정보를 단말(410)에 전송할 수 있다. 이 코드북제한정보는 하향링크 제어정보, 예를 들어 RRC 신호로 물리적 하향링크 공유채널(Physical Downlink Shared Channel, PDSCH)을 통해 기지국(420)으로부터 단말(410)에 전송될 수 있다. 이때 코드북제한정보는 PDSCH 이외에 물리적 하향링크 제어채널(Physical Downlink Control Channel, PDCCH)과 같은 다른 채널을 통해 기지국(420)으로부터 단말(410)로 전송될 수도 있다.

[115] 레이어 맵핑 단계(S610)에서 코드북제한정보는 하향링크 제어신호로 레이어에 맵핑될 수 있다.

[116] 기지국(420)은 각 셀(cell) 단위 또는 사용자(User Equipment) 단위로 사용할/사용하지 않을 프리코딩 행렬을 결정하고 사용하지 않을 프리코딩 행렬에 대한 코드북제한정보를 단말(410)에 전송할 수 있다. 이때 코드북제한정보는 제1 및 제2코드북들에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 포함하고 있다.

[117] 표 5 과 같이 랭크1에 대해 제1인덱스=0(PMI_1=0) 및 제2인덱스=1(PMI_2=1)에

대하여 코드북 제한을 결정되었을 경우 코드북제한정보는 비트맵형식으로 제1정보인 [0111111111111111]와 제2정보인 [1011]를 포함할 수 있다.

[118] 프리코딩 단계(S620)에서 레이어에 매핑된 데이터심볼을 자신의 코드북에서 선택한 제1프리코딩 행렬과 제2프리코딩 행렬을 이용하여 프리코딩할 수 있다. 이때 프리코딩 단계(S620)에서 단말과 같은 수신장치로부터 수신받은 제1인덱스와 제2인덱스에 대응하는 제1프리코딩 행렬과 제2프리코딩 행렬을 각각 이용하여 데이터 심볼들을 프리코딩할 수 있다. 이때 수신장치로부터 수신받는 제1인덱스와 제2인덱스는 표 3의 제1코드북과 표 4의 제2코드북에서 코드북제한정보에 의해 제한된 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 선정된 프리코딩 행렬들에 대한 인덱스들이다.

[119] 전술한 바와 같이 기지국과 같은 송신장치는 도 5를 참조하여 설명한 바와 같이 하나의 방향으로 편파된 적어도 하나의 안테나와 다른 방향으로 편파된 적어도 하나의 다른 안테나가 서로 교차하는 적어도 하나의 안테나쌍을 포함할 수 있다.

[120] 이때 수학식 3을 참조하여 설명한 바와 같이 제1프리코딩 행렬은 서로 교차하는 하나의 안테나와 다른 안테나 사이 프리코딩을 수행하는 프리코딩 행렬이며, 제2프리코딩 행렬은 하나의 안테나와 상기 다른 안테나의 위상차 보정을 수행하는 프리코딩 행렬일 수 있다.

[121] 이상, 또다른 실시예에 따른 송신장치의 통신방법에 대해 기재하였으나, 이하 또다른 실시예에 따른 수신장치의 통신방법에 대해 기재한다.

[122] 도 7은 또다른 실시예에 따른 수신장치의 통신방법의 흐름도이다.

[123] 또다른 실시예에 따른 수신장치의 통신방법(700)은 코드북제한정보를 송신장치로부터 수신하는 코드북제한정보 수신단계(S710)과 제1채널상태정보와 제2채널상태정보를 송신장치에 전송하는 채널정보 전송단계(S720)을 포함한다.

[124] 코드북제한정보 수신단계(S710)에서, 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 코드북제한정보로 각각 수신할 수 있다.이때 코드북제한정보는 제1 및 제2코드북들에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 포함하고 있다.채널정보 전송단계(S720)에서 코드북제한정보를 이용하여 코드북에서 제1프리코딩 행렬 또는 상기 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송할 수 있다.

[125] S710단계와 S720단계를 자세히 설명하면, 전술한 예에서 S710단계에서 수신장치가 랭크1에 대해 제1인덱스=0(PMI_1=0)에 대하여 코드북을 제한하는 비트맵형식의 제1정보인 [0111111111111111]와 제2정보인 [1011]를 수신한 경우, S720단계에서 수신장치는 표 5와 같이 제1인덱스=0(PMI_1=0)를 제외한

인덱스들, 즉 제1인덱스=0에 해당하는 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 제1프리코딩 행렬을 결정하고 그에 대한 제1채널상태정보를 기지국에 보고/피드백하고 제2인덱스=1(PMI_2=1)를 제외한 인덱스들, 즉 제2인덱스=1에 해당하는 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 제2프리코딩 행렬을 결정하고 그에 대한 제2채널상태정보를 기지국에 보고/피드백할 수 있다.

[126] 결과적으로 제1인덱스=0(PMI_1=0)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (**0**.1), (**0**.1), (**0**.2), (**0**.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=1(PMI_2=1)과 쌍을 이루는 제1인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.1), (1.1)… (14.1), (15.1)도 전체적으로 코드북이 제한된다.

[127] S710단계에서 수신장치가 랭크2에 대해 제1인덱스=1(PMI_1=1) 및 제2인덱스=2(PMI_2=2)에 대하여 코드북을 제한하는 비트맵형식의 제1정보인 [1011111111111111]와 제2정보인 [1101]를 수신한 경우 S720단계에서 수신장치는 표 5와 같이 랭크2에 대해 제1인덱스=1(PMI_1=1) 및 제2인덱스=2(PMI_2=2)를 제외한 제1프리코딩 행렬과 제2프리코딩 행렬을 결정하고 그에 대한 제1채널상태정보와 제2채널상태정보를 기지국에 보고/피드백할 수 있다.

[128] 결과적으로 제1인덱스=1(PMI_1=1)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (**1**.1), (**1**.1), (**1**.2), (**1**.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=2(PMI_2=2)과 쌍을 이루는 제1인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.2), (1.2)…(14.2), (15.2)도 전체적으로 코드북이 제한된다.

[129] 다시 말해, 코드북제한정보는 제1정보와 상기 제2정보를 포함하므로, 제1정보에 따라 제1프리코딩 행렬로 사용되는 것을 제한됨에 따라 사용이 제한된 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고 제2정보에 따라 제2프리코딩 행렬로 사용되는 것을 제한함에 따라 사용이 제한되는 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용을 제한할 수 있다.

[130] 랭크 3 내지 랭크 8도 동일한 방식으로 수신장치는 제1정보와 제2정보에서 지정한 프리코딩 행렬들을 제외하고 제1프리코딩 행렬과 제2프리코딩 행렬을 결정할 수 있다.

[131] 이상, 실시예들을 통해 다단 구조의 프리코더를 사용할 경우 코드북제한시 무선통신시스템에서 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 과정, 코드북제한정보와 채널생태정보를 송수신하는 MIMO 무선통신시스템, 이 무선통신시스템에서 송신장치와 수신장치의 송수신방법 또는 통신방법에 대해 상세히 기재하였다.

[132] 실시예들에 따라 다단 구조의 프리코더들 각각에 대해 프리코딩 행렬들을 제한하는 정보들을 결정하고 그 결정한 정보들을 포함하는 코드북제한정보를 전송하므로 코드북제한정보의 전송 오버헤드를 줄일 수 있다. 실시예들에 따라

무선통신시스템에서 코드북제한기법을 사용하므로 셀 간 간섭을 제어할 수 있다.

[133] 전술한 수식학 3을 통해 설명한 바와 같이 프리코딩 행렬의 정의에 따를 때 각 도메인 또는 안테나의 서브세트내에서의 프리코딩 게인은 제1프리코딩 행렬에 의해 결정된다. 즉, 전체 프리코딩 게인은 제1프리코딩 행렬에 대한 이득과 도메인 또는 서브세트간 위상차 보정(co-phasing) 작업을 수행하는 제2프리코더 행렬의 코딩 이득에 의해 결정될 수 있다. 이때 제2프리코딩 행렬은 도메인 또는 서브세트간 위상차 보정(co-phasing) 작업을 수행하는 프리코딩 행렬이므로 각 단말이 획득할 수 있는 최대 프리코딩 게인은 제1프리코딩 행렬에 의해 결정된다. 다시 말해 각 단말이 수신하는 신호의 전력 또는 수신 가능한 최대 전력은 제1프리코더 또는 제1프리코딩 행렬에 의해 결정되며, 제2프리코더 또는 제2프리코딩 행렬은 각 도메인 또는 안테나 서브세트에 수신된 신호의 위상 보정 작업을 수행할 뿐이다. 다중 접속에 의한 간섭은 제1프리코더 또는 제1프리코딩 행렬에 의해 크게 좌우된다.

[134] 도 8 내지 도 10은 실시예들에 따라 무선통신시스템에서 코드북제한기법을 사용하여 셀 간 간섭을 제어하는 개념도들이다.

[135] 도 8을 참조하면, 빔 포밍시 셀 경계 사용자 단말들(810a 내지 810d)은 셀 간 간섭이 발생할 수 있다. 예를 들어 810a 및 810b로 표시된 단말들은 도 8에 도시한 바와 같이 제1기지국과 제2기지국의 커버리지 내에 존재하기 때문에 제1기지국 또는 제1셀(820a)의 PMI_1=4 또는 PMI_1=6에 대한 제1프리코딩 행렬로 프리코딩한 신호 전송시 제2기지국 또는 제2셀(820b)의 PMI_1=13에 대한 제1프리코딩 행렬로 프리코딩한 신호 전송은 간섭을 일으킬 수 있다.

[136] 다시 말해 810a 및 810b로 표시된 단말들은 제1기지국 또는 제1셀(820a)의 PMI_1=4 또는 PMI_1=6에 대한 제1프리코딩 행렬로 프리코딩한 전송 신호와 제2기지국 또는 제2셀(820b)의 PMI_1=13에 대한 제1프리코딩 행렬로 프리코딩한 전송 신호를 모두 수신하므로 간섭을 일으킬 수 있다.

[137] 반대로 810c 및 810d로 표시된 단말들은 도 8에 도시한 바와 같이 제1기지국과 제2기지국의 커버리지 내에 존재하기 때문에 제1기지국(820a)의 PMI_1=8에 대한 제1프리코딩 행렬로 프리코딩한 신호 전송과 제2기지국(820b)의 PMI_1=2 또는 PMI_1=11에 대한 제1프리코딩 행렬로 프리코딩한 신호전송은 간섭을 일으킬 수 있다.

[138] 구체적으로 하나의 단말(810b)을 예를 들어 설명하면, 하나의 단말(810b)은 도 8에 도시한 바와 같이 제1기지국(820a) 또는 제2기지국(820b) 모두로부터 신호를 수신할 수 있다. 제1기지국(820a)은 하나의 단말(810b)에 신호를 전송하기 위하여 PMI_1=6에 해당하는 제1프리코딩 행렬을 사용하여 신호를 전송하며, 제2기지국(820b)은 하나의 단말(810b)에 신호를 전송하기 위하여 PMI_1=13에 해당하는 제1프리코더 행렬을 사용한다. 결과적으로 도 8에 도시한 바와 같이 하나의 단말(810b)에 제2기지국(820b)이 PMI_1=13을 사용하여 신호를 전송할 때

다른 단말(810a)은 하나의 단말(810b)에게 전송된 신호에 의해 다중 접속 간섭을 받게 된다.

[139] 제2기지국(820b)이 PMI_1=13에 해당하는 제1프리코더 행렬을 사용하지 않도록 코드북 제한을 할 경우, 단말(810b)은 제1기지국(820a)으로부터의 신호만을 수신받게 되므로 다중 간섭에 의한 셀 간 간섭을 사전에 방지할 수 있다.

[140] 또다른 단말들(810c, 810d)도 위에서 설명한 단말들(810a, 810b)와 동일한 셀간 간섭에 의한 다중 접속간섭을 받게 된다.

[141] 제1기지국(820a)이 PMI_1=8에 해당하는 제1프리코더 행렬을 사용하지 않도록 코드북 제한을 할 경우, 단말들(810c, 810d)은 제2기지국(820b)로부터 신호만을 수신받게 되므로 다중 간섭에 의한 셀 간 간섭을 사전에 방지할 수 있다.

[142] 도 9는 전술한 방식으로 코드북 제한을 함으로 셀간 간섭을 발생시킬 것이라 예상되는 제1프리코딩 행렬 또는 이에 대한 인덱스에 대하여 제한을 한 후 이에 근거하여 하향링크 MIMO을 수행한 것을 개념적으로 도시하고 있다.

[143] 도 9를 참조하면, 각 기지국들(820a, 820b)이 PMI_1=13과 PMI_1=8 또는 이들에 대응하는 제1프리코딩 행렬의 사용을 제한하는 PMI_1 기반 코드북 제한을 수행할 경우, 도 9에 도시한 바와 같이 셀간 간섭 발생을 피하거나 줄일 수 있다. 따라서, PMI_2에 대해서는 코드북 제한을 가하지 않고 PMI_1에만 코드북 제한을 가할 경우 전술한 셀간 간섭 제거 효과를 얻을 수 있다.

[144] 도 10을 참조하면, 810b로 표시한 단말은 제1기지국의 PMI_1=6과 제2기지국의 PMI_1=13에 대한 제1프리코딩 행렬로 프리코딩된 신호들을 수신하므로 간섭이 발생하고, 810c로 표시한 단말은 제1기지국의 PMI_1=8과 제2기지국의 PMI_1=2에 대한 제1프리코딩 행렬로 프리코딩된 신호들을 수신하므로 간섭이 발생할 수 있다. 이 경우 제1기지국은 PMI_1=6의 사용을 허가하고 PMI_1=2의 사용을 제한하고 반대로 제2기지국은 PMI_1=2의 사용을 허가하고 PMI_1=6의 사용을 제한하므로 단말들의 간섭을 제거할 수 있다.

[145] 다른 방식으로 이 경우 제1기지국은 PMI_1=8의 사용을 허가하고 PMI_1=13의 사용을 제한하고 반대로 제2기지국은 PMI_1=13의 사용을 허가하고 PMI_1=8의 사용을 제한하므로 단말들의 간섭을 제거할 수 있다.

[146] 다른 방식으로 제1기지국은 PMI_1=6과 PMI_1=8의 사용을 허가하고 제2기지국은 PMI_1=6과 PMI_1=8의 사용을 제한할 수도 있고, 반대로 제1기지국은 PMI_1=6과 PMI_1=8의 사용을 제한하고 제2기지국은 PMI_1=6과 PMI_1=8의 사용을 허가하여 단말들의 간섭을 제거할 수 있다.

[147] 이와 같이 각 기지국들(820a, 820b)이 PMI_1 기반 코드북 제한을 수행할 경우, 셀간 간섭 발생을 피하거나 줄일 수 있다. PMI_2에 대해서는 코드북 제한을 가하지 않고 PMI_1에만 코드북 제한을 가할 경우 전술한 셀간 간섭 제거 효과를 얻을 수 있다.

[148] 또한 PMI_2에 대해서만 코드북 제한을 가할 경우, 적은 비트수로 코드북을 제한할 수 있는 장점이 있으며, 프리코딩 게인을 직접적으로 제어하는 PMI_1에

제약을 걸지 않아 보다 정밀한 프리코딩이 가능하면서도 코드북 크기를 줄일 수 있다는 장점이 있다.

[149] 이상 도면을 참조하여 실시예들을 상세히 설명하였으나 본 발명은 이에 제한되지 않는다.

[150] 이상과 같은 실시예들은 상향/하향링크 MIMO 시스템에 적용될 수 있으며, 단일 셀(single cell) 환경뿐 아니라 다중 포인트 협력형 송수신 시스템(Coordinated multi-point transmission/reception System; CoMP) 및 이종 네트웍(heterogeneous network) 등 모든 상향/하향링크 MIMO 시스템에 적용될 수 있을 것이다.

[151] 이상의 설명은 본 발명의 기술 사상을 예시적으로 설명한 것에 불과한 것으로서, 본 발명이 속하는 기술 분야에서 통상의 지식을 가진 자라면 본 발명의 본질적인 특성에서 벗어나지 않는 범위에서 다양한 수정 및 변형이 가능할 것이다. 따라서, 본 발명에 개시된 실시예들은 본 발명의 기술 사상을 한정하기 위한 것이 아니라 설명하기 위한 것이고, 이러한 실시예에 의하여 본 발명의 기술 사상의 범위가 한정되는 것은 아니다. 본 발명의 보호 범위는 아래의 청구범위에 의하여 해석되어야 하며, 그와 동등한 범위 내에 있는 모든 기술 사상은 본 발명의 권리범위에 포함되는 것으로 해석되어야 할 것이다.

[152] **CROSS-REFERENCE TO RELATED APPLICATION**

[153] 본 특허출원은 2010년 7월 5일 한국에 출원한 특허출원번호 제 10-2010-0064573 호에 대해 미국 특허법 119(a)조 (35 U.S.C § 119(a))에 따라 우선권을 주장하며, 그 모든 내용은 참고문헌으로 본 특허출원에 병합된다. 아울러, 본 특허출원은 미국 이외에 국가에 대해서도 위와 동일한 동일한 이유로 우선권을 주장하면 그 모든 내용은 참고문헌으로 본 특허출원에 병합된다.

청구범위

[청구항 1] 제1프리코더와 제2프리코더를 포함하는 송신장치에서,
자신의 코드북에서 각 레이어에 대해 상기 제1프리코더의 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코더의 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 각각 결정하는 단계; 및
결정한 상기 제1정보와 상기 제2정보 중 적어도 하나를 포함하는 코드북제한정보를 수신장치에 전송하는 단계를 포함하는 송신장치의 통신방법.

[청구항 2] 제1항에 있어서,
상기 수신장치로부터 상기 수신장치가 상기 코드북제한정보를 이용하여 선택한 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 수신하는 단계; 및
수신한 상기 제1채널상태정보에 대응하는 제1프리코딩 행렬과 상기 제2채널상태정보에 대응하는 제2프리코딩 행렬을 이용하여 상기 제1프리코더와 상기 제2프리코더로 데이터 심볼들을 프리코딩하여 전송하는 단계를 추가로 포함하는 송신장치의 통신방법.

[청구항 3] 제1항에 있어서,
상기 제1정보와 상기 제2정보는 비트맵형식인 것을 특징으로 하는 송신장치의 통신방법.

[청구항 4] 제1항에 있어서,
상기 제1정보에 따라 상기 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고, 상기 제2정보에 따라 상기 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용이 제한되는 것을 특징으로 하는 송신장치의 통신방법.

[청구항 5] 제1항에 있어서,
상기 송신장치는 하나의 방향으로 편파된 적어도 하나의 안테나를 포함하는제1도메인과 다른 방향으로 편파된 적어도 하나의 다른 안테나를 포함하는 제2도메인이 서로 교차하는 적어도 하나의 안테나쌍을 포함하며,
상기 제1프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 별로 각각 프리코딩을 수행하는 프리코딩 행렬이며, 상기 제2프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 간 위상불일치의 영향을 제거하기 위한 위상차 보정을 수행하는 프리코딩 행렬인 것을 특징으로 하는 송신장치의 통신방법.

[청구항 6] 제5항에 있어서,
상기 제1프리코딩 행렬은 아래 수학식의 W1에 해당하며 상기 제2프리코딩 행렬은 아래 수학식의 W2에 해당하는 것을 특징으로 하는 송신장치의 통신방법.

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

상기 수학식에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한 공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 Λ는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

[청구항 7] 제5항에 있어서,
상기 안테나쌍의 개수는 4개인 것을 특징으로 하는 송신장치의 통신방법.

[청구항 8] 제2항에 있어서,
상기 제1채널상태정보와 상기 제2채널상태정보를 수신하는 단계에서, 상기 제1채널상태정보를 수신하는 주기와 상기 제2채널상태정보를 수신하는 주기가 다른 것을 특징으로 하는 송신장치의 통신방법.

[청구항 9] 제8항에 있어서,
상기 제1채널상태정보를 수신하는 주기가 상기 제2채널상태정보를 수신하는 주기보다 긴 것을 특징으로 하는 송신장치의 통신방법.

[청구항 10] 코드워드를 레이어에 매핑하는 레이어 맵퍼;
상기 코드워드가 상기 레이어 맵퍼에 의해 상기 레이어에 매핑된 데이터심볼을 자신의 코드북에서 선택한 제1프리코딩 행렬과 제2프리코딩 행렬을 이용하여 프리코딩하는 제1프리코더와 제2프리코더를 포함하는 프리코더;
프리코더로부터 출력된 신호들을 전송하는 안테나 어레이를 포함하며,
상기 코드워드는, 상기 코드북에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하는 송신장치.

[청구항 11] 제10항에 있어서,
상기 안테나 어레이는 제1프리코딩 행렬을 지시하는
제1채널상태정보와 제2프리코딩 행렬을 지시하는
제2채널상태정보를 수신하고,
상기 제1프리코더와 상기 제2프리코더 각각은 수신한 상기
제1채널상태정보에 대응하는 제1프리코딩 행렬과 상기
제2채널상태정보에 대응하는 제2프리코딩 행렬을 이용하여 상기
데이터 심볼들을 프리코딩하는 것을 특징으로 하는 송신장치.

[청구항 12] 제10항에 있어서,
상기 제1정보와 상기 제2정보는 비트맵형식인 것을 특징으로 하는
송신장치.

[청구항 13] 제10항에 있어서,
상기 제1정보에 따라 상기 제1프리코딩 행렬과 쌍을 이루는
제2프리코딩 행렬들의 사용이 제한되고, 상기 제2정보에 따라
상기 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의
사용이 제한되는 것을 특징으로 하는 송신장치.

[청구항 14] 제10항에 있어서,
상기 안테나 어레이는 하나의 방향으로 편파된 적어도 하나의
안테나를 포함하는 제1도메인과 다른 방향으로 편파된 적어도
하나의 다른 안테나를 포함하는 제2도메인이 서로 교차하는
적어도 하나의 안테나쌍을 포함하며,
상기 제1프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 별로
각각 프리코딩을 수행하는 프리코딩 행렬이며, 상기 제2프리코딩
행렬은 상기 제1도메인과 상기 제2도메인 간 위상불일치의 영향을
제거하기 위한 위상차 보정을 수행하는 프리코딩 행렬인 것을
특징으로 하는 송신장치.

[청구항 15] 제14항에 있어서,
상기 제1프리코딩 행렬은 아래 수학식의 W1에 해당하며 상기
제2프리코딩 행렬은 아래 수학식의 W2에 해당하는 것을 특징으로
하는 송신장치.

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

상기 수학식에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한

공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 ∧는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

[청구항 16] 제14항에 있어서,
상기 제1도메인과 상기 제2도메인은 서로 직교하는 것을 특징으로 하는 송신장치.

[청구항 17] 제14항에 있어서,
상기 안테나쌍의 개수는 4개인 것을 특징으로 하는 송신장치.

[청구항 18] 무선통신시스템에서,
각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하는 코드북제한정보를 수신하는 수신단계; 및
상기 코드북제한정보를 이용하여 코드북에서 상기 제1프리코딩 행렬 또는 상기 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송하는 전송단계를 포함하는 수신장치의 통신방법.

[청구항 19] 제18항에 있어서,
상기 제1정보와 상기 제2정보는 비트맵형식인 것을 특징으로 하는 수신장치의 통신방법.

[청구항 20] 제18항에 있어서,
상기 제1정보에 따라 상기 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고, 상기 제2정보에 따라 상기 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용이 제한되는 것을 특징으로 하는 수신장치의 통신방법.

[청구항 21] 제18항에 있어서,
상기 송신장치는 하나의 방향으로 편파된 적어도 하나의 안테나를 포함하는제1도메인과 다른 방향으로 편파된 적어도 하나의 다른 안테나를 포함하는 제2도메인이 서로 교차하는 적어도 하나의 안테나쌍을 포함하며,
상기 제1프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 별로 각각 프리코딩을 수행하는 프리코딩 행렬이며, 상기 제2프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 간 위상불일치의 영향을 제거하기 위한 위상차 보정을 수행하는 프리코딩 행렬인 것을 특징으로 하는 수신장치의 통신방법.

[청구항 22] 제21항에 있어서,

상기 제1프리코딩 행렬은 아래 수학식의 W1에 해당하며 상기 제2프리코딩 행렬은 아래 수학식의 W2에 해당하는 것을 특징으로 하는 수신장치의 통신방법.

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

상기 수학식에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한 공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 Λ는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

[청구항 23] 제18항에 있어서,
상기 전송단계에서, 상기 제1채널상태정보를 전송하는 주기와 상기 제2채널상태정보를 전송하는 주기가 다른 것을 특징으로 하는 수신장치의 통신방법.

[청구항 24] 제23항에 있어서,
상기 제1채널상태정보를 전송하는 주기가 상기 제2채널상태정보를 전송하는 주기보다 긴 것을 특징으로 하는 수신장치의 통신방법.

[청구항 25] 무선통신시스템에서,
각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제1정보 중 적어도 하나를 코드북제한정보로 수신하는 안테나 어레이; 및
상기 코드북제한정보를 이용하여 코드북에서 상기 제1프리코딩 행렬 또는 상기 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송하는 채널정보 피드백장치를 포함하는 수신장치.

[청구항 26] 제25항에 있어서,
상기 제1정보와 상기 제2정보는 비트맵형식인 것을 특징으로 하는 수신장치.

[청구항 27] 제25항에 있어서,
상기 제1정보에 따라 상기 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고, 상기 제2정보에 따라

상기 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용이 제한되는 것을 특징으로 하는 수신장치.

[청구항 28] 제25항에 있어서,
상기 송신장치는 하나의 방향으로 편파된 적어도 하나의 안테나를 포함하는제1도메인과 다른 방향으로 편파된 적어도 하나의 다른 안테나를 포함하는 제2도메인이 서로 교차하는 적어도 하나의 안테나쌍을 포함하며,
상기 제1프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 별로 각각 프리코딩을 수행하는 프리코딩 행렬이며, 상기 제2프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 간 위상불일치의 영향을 제거하기 위한 위상차 보정을 수행하는 프리코딩 행렬인 것을 특징으로 하는 수신장치.

[청구항 29] 제28항에 있어서,
상기 제1프리코딩 행렬은 아래 수학식의 W1에 해당하며 상기 제2프리코딩 행렬은 아래 수학식의 W2에 해당하는 것을 특징으로 하는 수신장치.

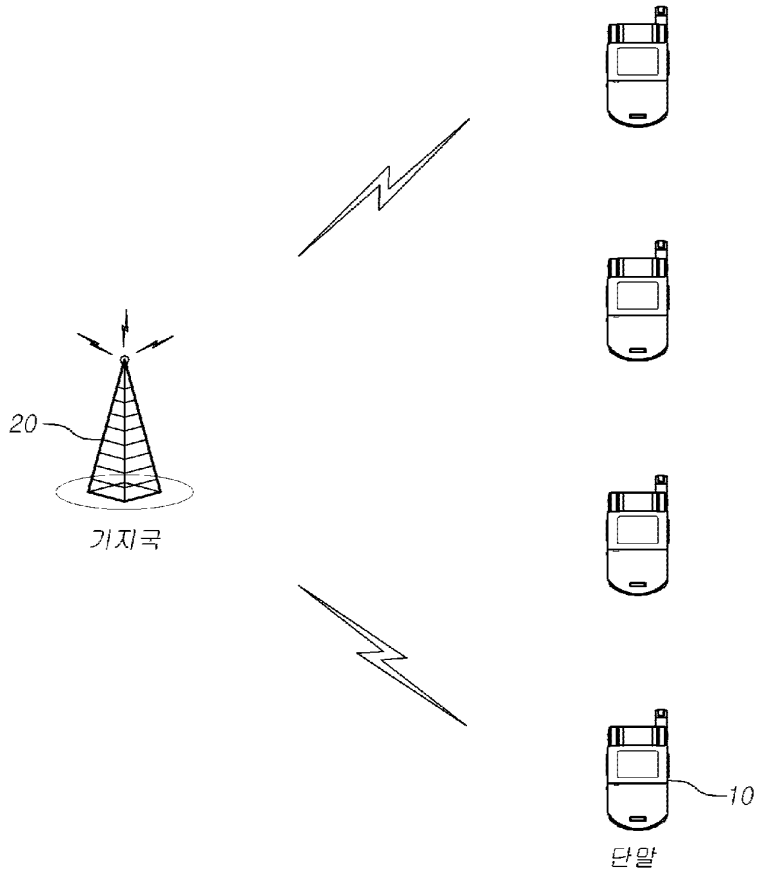
$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

상기 수학식에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한 공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 Λ는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

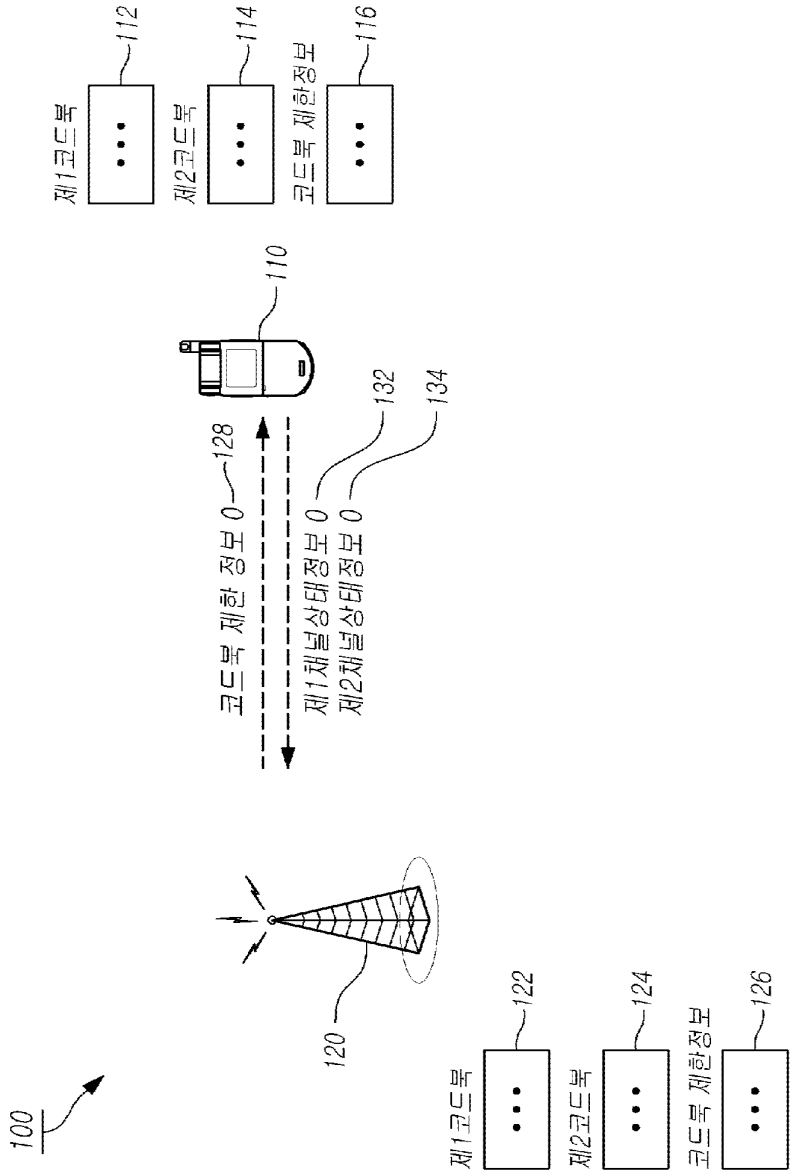
[청구항 30] 제25항에 있어서,
상기 제1채널상태정보를 전송하는 주기와 상기 제2채널상태정보를 전송하는 주기가 다른 것을 특징으로 하는 수신장치.

[청구항 31] 제30항에 있어서,
상기 제1채널상태정보를 전송하는 주기가 상기 제2채널상태정보를 전송하는 주기보다 긴 것을 특징으로 하는 수신장치.

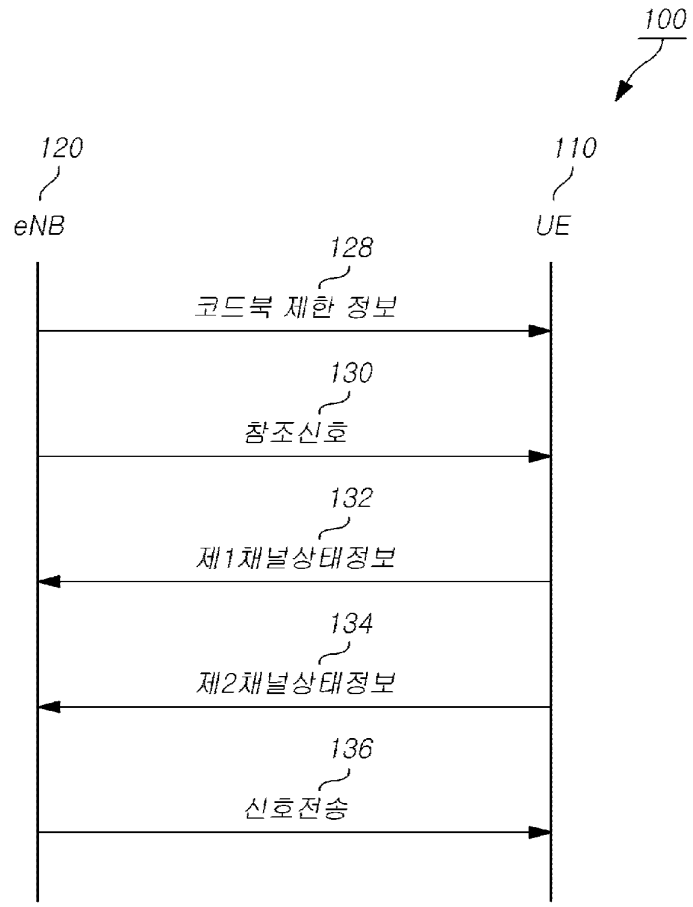
[Fig. 1]



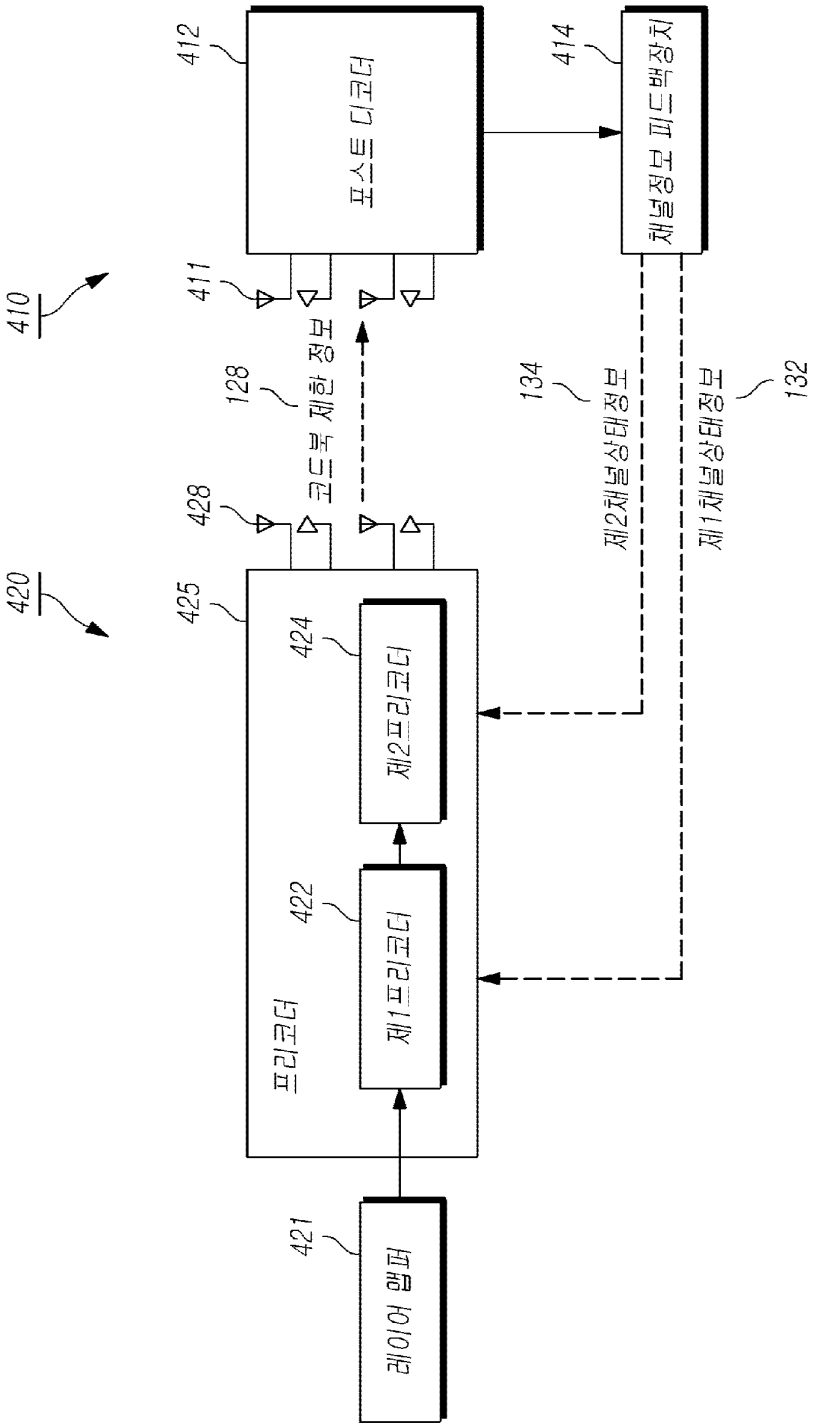
[Fig. 2]


112
114
116
제1코드북
제2코드북
코드북 제한정보
110
128
132
134
코드북 제한 정보 0
제1채널상태정보 0
제2채널상태정보 0
120
122
124
126
제1코드북
제2코드북
코드북 제한정보
100

[Fig. 3]


100
120
eNB
110
UE
128
코드북 제한 정보
130
참조신호
132
제1채널상태정보
134
제2채널상태정보
136
신호전송

[Fig. 4]

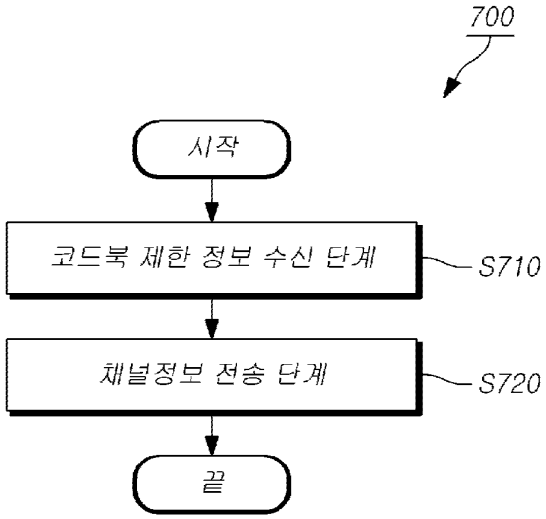

410
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128
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포스트 디코더
채널정보 피드백장치
코드북 제한 정보
제2채널상태정보
제1채널상태정보
프리코더
제2프리코더
제1프리코더
레이어 맵퍼

[Fig. 5]

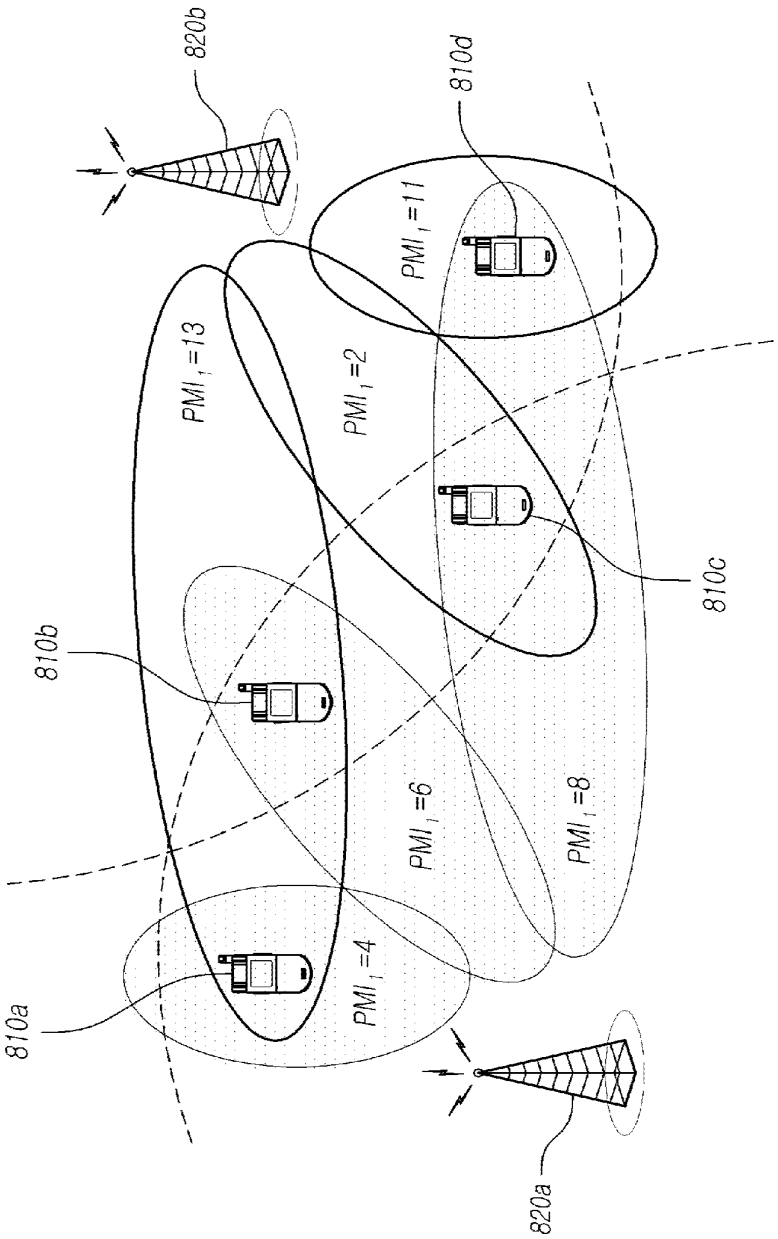
[Fig. 6]

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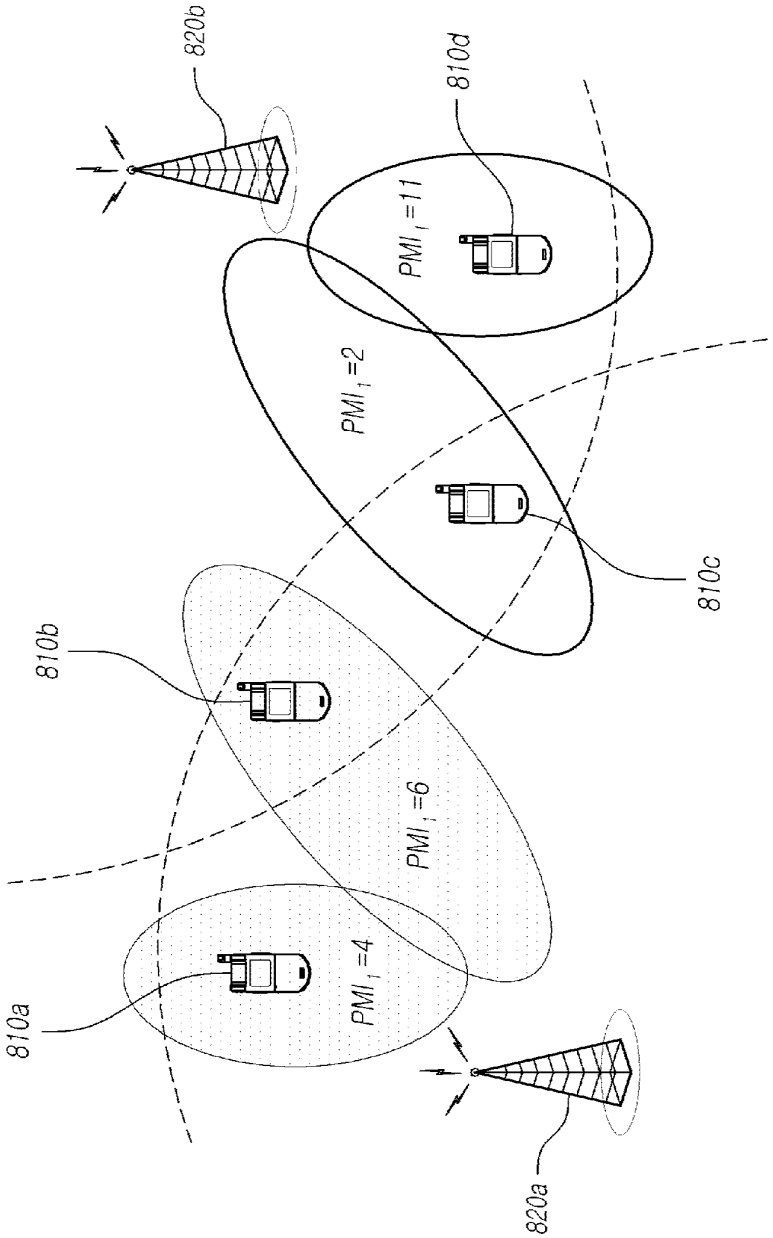
[Fig. 7]



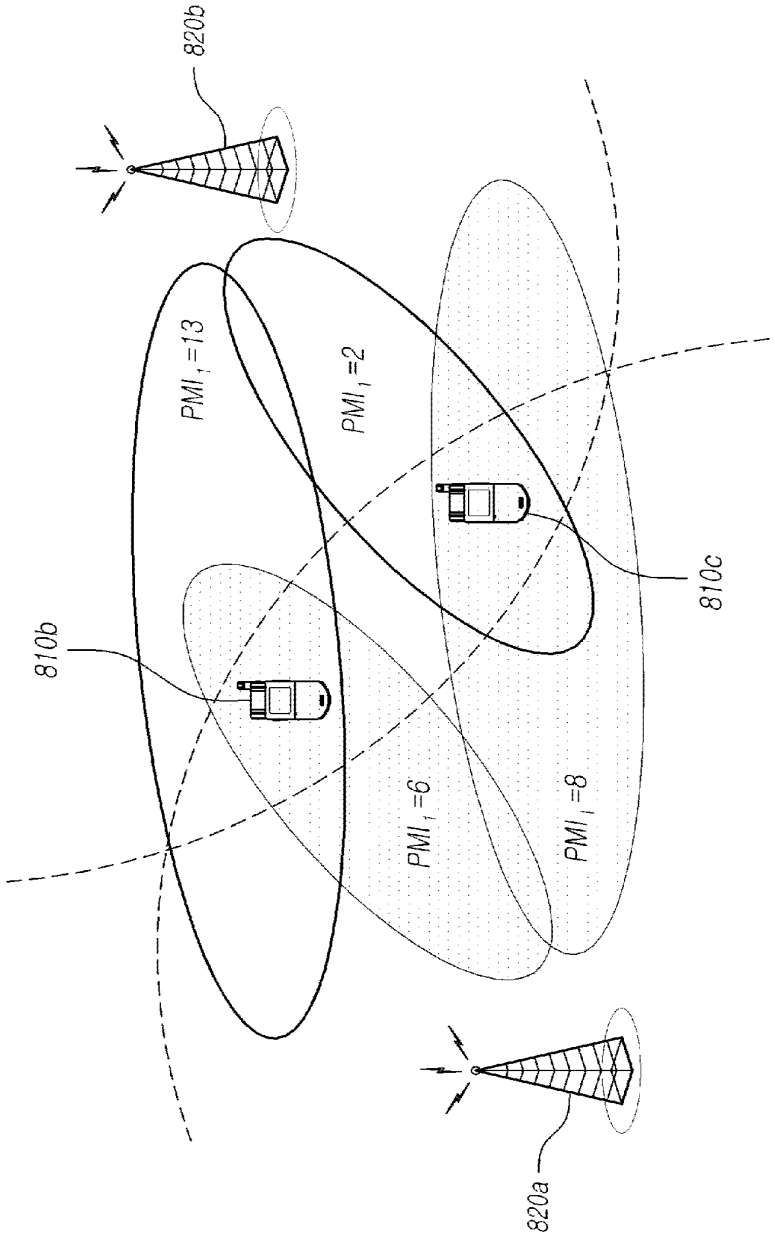
[Fig. 8]


820b
810d
PMI1=11
PMI1=13
PMI1=2
810c
810b
PMI1=6
PMI1=8
PMI1=4
810a
820a

[Fig. 9]



[Fig. 10]



PCT 출원서

출력(전자적 형태가 원본)

0	**수리관청 전용**	
0-1	국제출원번호	**PCT/KR2011/004835**
0-2	국제출원일자	**2011년 07월 01일 (01.07.2011)**
0-3	수리관청 명칭 및 "PCT 국제출원"	**RO/KR**

0-4	**서식 PCT/RO/101 - PCT 출원서**	
0-4-1	우측에 기재된 바와 같이 작성되었다.	**PCT-SAFE** **버전 3.51.047.223 MT/FOP 20101001/0.20.5.18**
0-5	**신청** 아래 서명인은 본 국제 출원서가 특허협력조약에 의해 처리될 것을 청구합니다.	
0-6	**출원인이 지정한 수리관청**	**대한민국 특허청 (RO/KR)**
0-7	**출원인 또는 대리인의 서류참조기호**	**PCT11-354**
I	**발명의 명칭**	**송신장치 및 그 통신방법, 수신장치, 그 통신방법**
II	**출원인**	
II-1	이 사람은	오직 출원인
II-2	우측 지정국에 관한 출원인	미국을 제외한 모든 지정국
II-4ko	성명	**(주)팬택**
II-4en	Name:	**PANTECH CO.,LTD.**
II-5ko	주소	서울시 마포구 상암동 **DMC, I-2,** 팬택빌딩 **121-270** 대한민국
II-5en	Address:	**Pantech Bldg., I-2, DMC, Sangam-dong, Mapo-gu,** **Seoul, 121-270** **Republic of Korea**
II-6	국적	대한민국 **KR**
II-7	거주국	대한민국 **KR**
II-8	전화번호	**+82-2-2030-0114**
II-9	팩스번호	**+82-2-2030-2521**
II-10	이메일 주소	**kwon.hyukjoon@pantech.com**
II-11	출원인 코드	**1-1998-004053-1**

PCT 출원서

출력(전자적 형태가 원본)

III-1	**출원인 및/또는 발명자**	
III-1-1	이 사람은	출원인 겸 발명자
III-1-2	우측 지정국에 관한 출원인	오직 미국만
III-1-4ko	성명	박경민
III-1-4en	Name (LAST, First):	**PARK, Kyoungmin**
III-1-5ko	주소	서울시 마포구 상암동 **DMC, I-2,** 팬택빌딩 **121-270** 대한민국
III-1-5en	Address:	**Pantech Bldg., I-2, DMC, Sangam-dong, Mapo-gu, Seoul, 121-270** **Republic of Korea**
III-1-6	국적	대한민국 **KR**
III-1-7	거주국	대한민국 **KR**
IV-1	**대리인 또는 대표자** 아래에 기재된 자는 관할 국제기관에 대하여 우측에 표시된 자격으로 출원인을 대리하는 것으로 선임되었다.	대리인 **(agent)**
IV-1-1ko	성명	김은구
IV-1-1en	Name (LAST, First):	**KIM, Eungu**
IV-1-2ko	주소	서울특별시 강남구 역삼동 **636-15** 상원빌딩 **2**층 **135-908** 대한민국
IV-1-2en	Address:	**2F, Sangwon Bld., 636-15 Yeoksam-dong, Gangnam-gu, Seoul, 135-908** **Republic of Korea**
IV-1-3	전화번호	**+82-2-568-6177**
IV-1-4	팩스번호	**+82-2-568-6176**
IV-1-5	이메일 주소	**ip@highestip.com**
IV-1-5(a)	이메일 사용동의 수리관청, 국제조사기관, 국제사무국, 국제예비심사기관이 필요 시 이 이메일 주소를 사용하여 이 국제 출원과 관련하여 발행된 통지서를 송부할 것에 동의한다.	서면 통지서에 앞서 선람용 사본 송부
IV-1-6	대리인 코드	**9-1999-000318-1**
IV-2	**추가 대리인**	최초 기재된 대리인과 동일한 주소를 갖는 새로운 대리인(들)
IV-2-1ko	성명	송, 해모**(9-2002-000179-4)**
IV-2-1en	Name(s)	**SONG, Haemo(9-2002-000179-4)**

PCT 출원서

출력(전자적 형태가 원본)

V	지정국		
V-1	**본 출원서의 제출로, 규칙 4.9(a)에 따라, 부여될 수 있는 모든 종류의 권리 보호를 위하여, 그리고 해당하는 경우 지역특허 및 국내특허 모두를 위하여 당해 국제출원일에 PCT에 기속되는 모든 체약국이 지정된다.**		
V-2	**V-2란은 출원서 제출시 또는 규칙 26의2.1에 의해 그 이후 출원서 제6기재란에 위 특정 관련 체약국의 국내 선출원에 대한 우선권주장이 포함되어 있을 경우 당해 체약국의 국내법에 의해 해당 국내 선출원의 효력이 상실되는 것을 방지하기 위한 목적으로 당해 체약국의 지정을 제외하는 데에만 사용될 수 있다 (지정 제외시 이의 취소 불가능).**	**KR**	
VI-1	**선국내출원에 대한 우선권 주장**		
VI-1-1	출원일	**2010년 07월 05일 (05.07.2010)**	
VI-1-2	출원번호	**10-2010-0064573**	
VI-1-3	국가	**KR**	
VI-2	**우선권 주장 요청** 수리관청에 대하여 위에 명시된 선출원의 인증등본을 준비하여 국제사무국에 송부하여 줄 것을 신청한다.	**VI-1**	
VI-3	**인용에 의한 보완** 조약 제11조(1)(iii)(d) 또는 (e)에서 규정하는 국제출원의 요소, 또는 규칙 20.5(a)에서 규정하는 명세서, 청구 범위 또는 도면의 일부가 본 국제출원에는 포함되어 있지 않지만 조약 제11조(1)(iii) 규정의 요소 중 하나 이상이 수리관청에 최초로 접수된 날에 우선권주장의 기초가 된 선출원에 완전히 포함되어 있는 경우, 그 요소 또는 부분은 규칙 20.6 규정에 의한 확인을 조건으로, 규칙 20.6의 규정과 관련하여 본 국제출원에 있어서 인용에 의해 보완된다.		
VII-1	**국제조사기관(ISA) 선택**	**대한민국 특허청 (ISA/KR)**	
VIII	**선언서**	선언서 개수	
VIII-1	발명자의 동일성에 관한 선언	-	
VIII-2	국제출원일에 특허출원 및 특허를 받을 수 있는 출원인의 자격에 관한 선언	-	
VIII-3	국제출원일에 선출원의 우선권을 주장할 수 있는 출원인의 자격에 관한 선언	-	
VIII-4	발명자 선언(미국에 대한 지정의 경우에 한함)	-	
VIII-5	신규성을 해치지 아니하는 개시 또는 신규성 상실의 예외에 관한 선언	-	
IX	**체크 리스트**	용지 수	전자적 파일 첨부
IX-1	출원서(선언서 포함)	**4**	✓
IX-2	명세서	**22**	✓
IX-3	청구범위	**6**	✓
IX-4	요약서	**1**	✓
IX-5	도면	**9**	✓
IX-7	용지매수 소계	**42**	

PCT 출원서

출력(전자적 형태가 원본)

	첨부 항목	서면 첨부	전자적 파일 첨부
IX-8	수수료 계산 용지	-	✓
IX-11	포괄위임장 사본	-	✓
IX-18	PCT-SAFE 전자출원 매체	-	-
IX-20	**요약서에 수반되어야 할 도면 번호**	**3**	
IX-21	국제출원의 출원 언어	한국어	
X-1	출원인, 대리인 또는 대표자의 서명 또는 날인	**(PKCS7 전자서명)**	
X-1-1	성명	김 은구	
X-1-2	서명인의 성명		
X-1-3	권한		

수리관청 전용

10-1	국제출원으로 제출된 서류의 실제 접수일	**2011년 07월 01일 (01.07.2011)**
10-2	도면	
10-2-1	접수	
10-2-2	미접수	
10-3	국제출원으로 제출된 서류를 완성하는 서류 또는 도면의 추후 기간내 제출에 따른 정정된 실제 접수일	
10-4	PCT 제11조(2)에 따라 제출이 요구된 보완서로서 기간내 제출된 보완서의 접수일	
10-5	국제조사기관(ISA)	**ISA/KR**
10-6	조사료 납부시까지 지연된 조사용 사본의 송부	

국제 사무국 전용

11-1	국제 사무국의 기록원본 접수일	

특 허 협 력 조 약
(PATENT COOPERATION TREATY)

발신 : 국제조사기관

수신 :
김 은구

서울특별시 강남구 역삼동 636-15 상원빌딩 2층
135-908 대한민국

PCT

조사용사본 수령 통지서

(PCT 규칙 25.1)

발송일 *(일/월/년)*	2011년 07월 12일 (12.07.2011)

출원인 또는 대리인의 서류참조기호	중요통지
PCT11-354	

국제출원번호	국제출원일*(일/월/년)*	우선일*(일/월/년)*
PCT/KR2011/004835	**2011년 07월 01일 (01.07.2011)**	2010년 07월 05일 (05.07.2010)

출원인
(주)팬택 등

1. 국제조사기관 및 수리관청이 동일한 관청이 아닌 경우:
본 국제조사기관이 아래 기재된 날에 국제출원의 조사용사본을 수령하였음을 출원인에게 통지합니다.

국제조사기관 및 수리관청이 동일한 관청인 경우:
아래 기재된 날에 국제출원의 조사용사본을 수령하였음을 출원인에게 통지합니다.

2011년 07월 11일 (11.07.2011) *(접수일)*

2. ☐ 조사용사본에 전자적 형태의 핵산염기 및/또는 아미노산 서열목록이 첨부되어 있습니다.

3. ☐ 조사용사본에 전자적 형태의 핵산염기 및/또는 아미노산 서열목록이 포함되어 있습니다.

4. 국제조사보고서 및 국제조사기관의 견해서 작성기한
국제조사보고서 및 국제조사기관의 견해서의 작성기한은 상기의 접수일부터 3월 또는 우선일부터 9월중 늦게 만료하는 날까지임을 통지합니다(조약규칙 42.1 및 43의 2.1(a)).

이 통지서의 사본은 국제사무국에 송부되었습니다. 다만, 1.의 첫 번째 문장에 해당하는 경우에는 수리관청에도 송부됩니다.

ISA/KR의 명칭 및 우편주소
대한민국 특허청
(302-701) 대전광역시 서구 청사로 189,
정부대전청사
팩스번호 82-42-472-7140

특허청장
전화번호 82-42-481-8753

서식 PCT/ISA/202 (2009년 7월)

특 허 협 력 조 약
(PATENT COOPERATION TREATY)

발신:수리관청

수신:
김 은구

서울특별시 강남구 역삼동 636-15 상원빌딩 2층
135-908 대한민국

PCT

국제출원번호 및 국제출원일 통지서

(PCT 규칙 20.2(c))

발송일 *(일/월/년)*	2011년 07월 11일 (11.07.2011)
출원인 또는 대리인의 서류참조기호 PCT11-354	**중요통지사항**

국제출원번호	국제출원일 *(일/월/년)*	우선일 *(일/월/년)*
PCT/KR2011/004835	**2011년 07월 01일 (01.07.2011)**	2010년 07월 05일 (05.07.2010)

출원인
(주)팬택 등

발명의 명칭
송신장치 및 그 통신방법, 수신장치, 그 통신방법

1. 이 국제출원은 위에 기재된 바와 같이 국제출원번호와 국제출원일이 부여되었습니다.

2. 이 국제출원의 기록원본은:

☐ _____ 자로 국제사무국에 송부되었습니다.

☐ 아래의 사유로 인하여 아직 국제사무국에 송부되지 않았으며,이 통지서의 사본은 국제사무국에 송부되었습니다*:

☐ 국가안전보장에 필요한 허가를 얻지 못했음

☐ 기타 *(이유를 상술)*:

* 국제사무국은 수리관청에 의한 기록원본의 송달을 감시하고 그 접수사실을 출원인에게 통지합니다. (서식 PCT/IB/301). 국제사무국은 우선일부터 14월이 경과할 때까지 기록원본을 수령하지 않은 때에는 출원인에게 이를 통지합니다. (규칙 22.1(c)).

수리관청명칭 및 우편주소
대한민국 특허청
(302-701) 대전광역시 서구 청사로 189,
정부대전청사
팩스번호: 82-42-472-7140

특허청장

전화번호: 82-42-481-5281

서식 PCT/RO/105 (2008년 7월)

ADVANCE E-MAIL

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF RECEIPT OF RECORD COPY

(PCT Rule 24.2(a))

To:

KIM, Eungu
2F, Sangwon Bld., 636-15 Yeoksam-dong,
Gangnam-gu
Seoul 135-908
RÉPUBLIQUE DE CORÉE

Date of mailing *(day/month/year)*	IMPORTANT NOTIFICATION
01 September 2011 (01.09.2011)	
Applicant's or agent's file reference	International application No.
PCT11-354	PCT/KR2011/004835

The applicant is hereby **notified** that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

PANTECH CO., LTD. (for all designated States except US)
PARK, Kyoungmin (for US)

International filing date: 01 July 2011 (01.07.2011)
Priority date(s) claimed: 05 July 2010 (05.07.2010)
Date of receipt of the record copy by the International Bureau: 12 July 2011 (12.07.2011)
List of designated Offices:

AP: BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW
EA: AM, AZ, BY, KG, KZ, MD, RU, TJ, TM
EP: 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
OA: BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG
National: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, 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, IS, JP, KE, KG, KM, KN, KP, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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

ATTENTION: The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau. **In addition, the applicant's attention is drawn to:**

- time limits for entry into the national phase (see www.wipo.int/pct/en/texts/time_limits.htmland *PCT Applicant's Guide*, National Phase, especially Chapters 3 and 4)
- requirements regarding priority documents (if applicable) (see *PCT Applicant's Guide*, International Phase, paragraph 5.070)

A copy of this notification is being sent to the receiving Office and to the International Searching Authority.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 70 90

Authorized officer
Parianou Christina
e-mail pt12.pct@wipo.int
Telephone No. +41 22 338 74 12

ADVANCE E-MAIL

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING SUBMISSION, OBTENTION OR TRANSMITTAL OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

To:

KIM, Eungu
2F, Sangwon Bld., 636-15 Yeoksam-dong,
Gangnam-gu
Seoul 135-908
RÉPUBLIQUE DE CORÉE

Date of mailing *(day/month/year)* 02 September 2011 (02.09.2011)	
Applicant's or agent's file reference PCT11-354	**IMPORTANT NOTIFICATION**
International application No. PCT/KR2011/004835	International filing date *(day/month/year)* 01 July 2011 (01.07.2011)
International publication date *(day/month/year)* **Not yet published**	Priority date *(day/month/year)* 05 July 2010 (05.07.2010)
Applicant PANTECH CO., LTD. et al	

The applicant is hereby notified of the date of receipt (or of obtaining by the International Bureau) of the priority document(s) relating to all earlier application(s) whose priority is claimed. Unless otherwise indicated by the letters "NR", in the right-hand column or by an asterisk appearing next to the date of receipt, **the priority document concerned was submitted or transmitted to or obtained by the International Bureau in compliance with Rule 17.1(a), (b) or (b-*bis*)**. This Form replaces any previously issued notification concerning submission, transmittal or obtaining of priority documents.

Priority date	Priority application No.	Country or regional Office or PCT receiving Office	Date of receipt of priority document
05 July 2010 (05.07.2010)	10-2010-0064573	KR	19 July 2011 (19.07.2011)

The letters "NR" denote a priority document which, on the date of mailing of this Form, had not yet been received or obtained by the International Bureau in compliance with Rule 17.1(a), (b) or (b-*bis*). Where the applicant has failed to either submit, request to prepare and transmit or obtain and transmit, or to request the International Bureau to obtain the priority document within the applicable time limit under that Rule, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

An asterisk "*" next to a date of receipt, denotes a priority document submitted or transmitted to or obtained by the International Bureau but not in compliance with Rule 17.1(a), (b) or (b-*bis*) (the priority document was received after the time limit prescribed in Rule 17.1(a); the request to prepare and transmit the priority document was submitted to the receiving Office after the applicable time limit under Rule 17.1(b) or the request to the receiving Office or the International Bureau to obtain the priority document was made after the applicable time limit under Rule 17.1(b-*bis*)). Even though the priority document was not furnished in compliance with Rule 17.1(a), (b) or (b-*bis*), the International Bureau will nevertheless transmit a copy of the document to the designated Offices, for their consideration. In case such a copy is not accepted by the designated Office as the priority document, Rule 17.1(c) provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 70 90

Authorized officer
Philippe Becamel
e-mail pt12.pct@wipo.int
Telephone No. +41 22 338 74 12

PATENT COOPERATION TREATY

ADVANCE E-MAIL

From the INTERNATIONAL BUREAU

PCT

FIRST NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION (TO DESIGNATED OFFICES WHICH DO NOT APPLY THE 30 MONTH TIME LIMIT UNDER ARTICLE 22(1))

(PCT Rule 47.1(c))

To:

KIM, Eungu
2F, Sangwon Bld., 636-15 Yeoksam-dong, Gangnam-gu
Seoul 135-908
RÉPUBLIQUE DE CORÉE

Date of mailing *(day/month/year)* 09 February 2012 (09.02.2012)		
Applicant's or agent's file reference PCT11-354	**IMPORTANT NOTICE**	
International application No. PCT/KR2011/004835	International filing date *(day/month/year)* 01 July 2011 (01.07.2011)	Priority date *(day/month/year)* 05 July 2010 (05.07.2010)
Applicant PANTECH CO., LTD. et al		

1. **ATTENTION**: For any designated Office(s), for which the time limit under Article 22(1), as in force from 1 April 2002 (30 months from the priority date), **does apply**, please see Form PCT/IB/308(Second and Supplementary Notice) (to be issued promptly after the expiration of 28 months from the priority date).

2. Notice is hereby given that the following designated Office(s), for which the time limit under Article 22(1), as in force from 1 April 2002, **does not apply**, has/have requested that the communication of the international application, as provided for in Article 20, be effected under Rule 93*bis*.1. The International Bureau has effected that communication on the date indicated below:
12 January 2012 (12.01.2012)

   None

   In accordance with Rule 47.1(c-*bis*)(i), those Offices will accept the present notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

3. The following designated Offices, for which the time limit under Article 22(1), as in force from 1 April 2002, **does not apply**, have not requested, as at the time of mailing of the present notice, that the communication of the international application be effected under Rule 93*bis*.1 :

   LU, TZ, UG

   In accordance with Rule 47.1(c-*bis*)(ii), those Offices accept the present notice as conclusive evidence that the Contracting State for which that Office acts as a designated Office does not require the furnishing, under Article 22, by the applicant of a copy of the international application.

4. **TIME LIMITS for entry into the national phase**

   For the designated Office(s) listed above, and unless a demand for international preliminary examination has been filed before the expiration of **19 months** from the priority date (see Article 39(1)), the applicable time limit for entering the national phase will, **subject to what is said in the following paragraph,** be **20 MONTHS** from the priority date.

   In practice, **time limits other than the 20-month time limit** will continue to apply, for various periods of time, in respect of certain of the designated Offices listed above. For **regular updates on the applicable time limits** (20 or 21 months, or other time limit), Office by Office, refer to the *PCT Gazette*, the *PCT Newsletter* and the *PCT Applicant's Guide*, Volume II, National Chapters, all available from WIPO's Internet site, at http://www.wipo.int/pct/en/index.html.

   It is the applicant's **sole responsibility** to monitor all these time limits.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 82 70

Authorized officer
Philippe Bécamel

e-mail: pt01.pct@wipo.int

PATENT COOPERATION TREATY

ADVANCE E-MAIL

From the INTERNATIONAL BUREAU

PCT

SECOND AND SUPPLEMENTARY NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION (TO DESIGNATED OFFICES WHICH APPLY THE 30 MONTH TIME LIMIT UNDER ARTICLE 22(1))

(PCT Rule 47.1(c))

To:

KIM, Eungu
2F, Sangwon Bld., 636-15 Yeoksam-dong, Gangnam-gu
Seoul 135-908
RÉPUBLIQUE DE CORÉE

Date of mailing *(day/month/year)* 08 November 2012 (08.11.2012)	
Applicant's or agent's file reference PCT11-354	**IMPORTANT NOTICE**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/KR2011/004835	01 July 2011 (01.07.2011)	05 July 2010 (05.07.2010)

Applicant: PANTECH CO., LTD. et al

1. **ATTENTION**: For any designated Office(s), for which the time limit under Article 22(1), as in force from 1 April 2002 (30 months from the priority date), **does not apply**, please see Form PCT/IB/308(First Notice) issued previously.

2. Notice is hereby given that the following designated Office(s), for which the time limit under Article 22(1), as in force from 1 April 2002, **does apply**, has/have requested that the communication of the international application, as provided for in Article 20, be effected under Rule 93*bis*.1. The International Bureau has effected that communication on the date indicated below:
12 January 2012 (12.01.2012)

AU, AZ, BY, CN, CO, DZ, EP, HU, KG, KP, MD, MK, MY, MZ, NA, NG, PG, RU, SY, TM, US

In accordance with Rule 47.1(c-*bis*)(i), those Offices will accept the present notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

3. The following designated Offices, for which the time limit under Article 22(1), as in force from 1 April 2002, **does apply**, have not requested, as at the time of mailing of the present notice, that the communication of the international application be effected under Rule 93*bis*.1 :

AE, AG, AL, AM, AO, AP, AT, BA, BB, BG, BH, BR, BW, BZ, CA, CH, CL, CR, CU, CZ, DE, DK, DM, DO, EA, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, ID, IL, IN, IS, JP, KE, KM, KN, KZ, LA, LC, LK, LR, LS, LT, LY, MA, ME, MG, MN, MW, MX, NI, NO, NZ, OA, OM, PE, PH, PL, PT, RO, RS, SC, SD, SE, SG, SK, SL, SM, ST, SV, TH, TJ, TN, TR, TT, UA, UZ, VC, VN, ZA, ZM, ZW

In accordance with Rule 47.1(c-*bis*)(ii), those Offices accept the present notice as conclusive evidence that the Contracting State for which that Office acts as a designated Office does not require the furnishing, under Article 22, by the applicant of a copy of the international application.

4. **TIME LIMITS for entry into the national phase**

For the designated or elected Office(s) listed above, the applicable time limit for entering the national phase will, **subject to what is said in the following paragraph,** be **30 MONTHS** from the priority date.

In practice, **time limits other than the 30-month time limit** will continue to apply, for various periods of time, in respect of certain of the designated or elected Office(s) listed above. For **regular updates on the applicable time limits** (30 or 31 months, or other time limit), Office by Office, refer to the *PCT Gazette*, the *PCT Newsletter* and the *PCT Applicant's Guide*, Volume II, National Chapters, all available from WIPO's Internet site, at http://www.wipo.int/pct/en/index.html.

It is the applicant's **sole responsibility** to monitor all these time limits.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 82 70

Authorized officer
Philippe Bécamel

e-mail: pt01.pct@wipo.int

PATENT COOPERATION TREATY

ADVANCE E-MAIL

PCT

NOTIFICATION CONCERNING
AVAILABILITY OF THE PUBLICATION
OF THE INTERNATIONAL APPLICATION

From the INTERNATIONAL BUREAU

To:

KIM, Eungu
2F, Sangwon Bld., 636-15 Yeoksam-dong, Gangnam-gu
Seoul 135-908
RÉPUBLIQUE DE CORÉE

Date of mailing *(day/month/year)* 12 January 2012 (12.01.2012)	
Applicant's or agent's file reference PCT11-354	**IMPORTANT NOTICE**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/KR2011/004835	01 July 2011 (01.07.2011)	05 July 2010 (05.07.2010)

Applicant
PANTECH CO., LTD. et al

The applicant is hereby **notified** that the International Bureau:

☒ has **published** the above-indicated international application on 12 January 2012 (12.01.2012) under No. WO 2012/005476

☐ has **republished** the above-indicated international application on under No. WO
For an explanation as to the reason for this republication of the international application, reference is made to INID codes (15), (48) or (88) (*as the case may be*) on the front page of the published international application.

A copy of the international application is available for viewing and downloading on WIPO's website at the following address: www.wipo.int/pctdb (in the appropriate field of the structured search, enter the PCT or WO number).

The applicant may also obtain a paper copy of the published international application from the International Bureau by sending an e-mail to patentscope@wipo.int or by submitting a written request to the contact details provided below.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 82 70

Authorized officer
Philippe Bécamel

e-mail: pt01.pct@wipo.int

PATENT COOPERATION TREATY

ADVANCE E-MAIL

PCT

From the INTERNATIONAL BUREAU

NOTIFICATION CONCERNING
AVAILABILITY OF THE PUBLICATION
OF THE INTERNATIONAL APPLICATION

To:

KIM, Eungu
2F, Sangwon Bld., 636-15 Yeoksam-dong, Gangnam-gu
Seoul 135-908
RÉPUBLIQUE DE CORÉE

Date of mailing *(day/month/year)*
01 March 2012 (01.03.2012)

Applicant's or agent's file reference
PCT11-354

IMPORTANT NOTICE

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/KR2011/004835	01 July 2011 (01.07.2011)	05 July 2010 (05.07.2010)

Applicant
PANTECH CO., LTD. et al

The applicant is hereby **notified** that the International Bureau:

☐ has **published** the above-indicated international application on under No. WO

☒ has **republished** the above-indicated international application on 01 March 2012 (01.03.2012) under No. WO 2012/005476
For an explanation as to the reason for this republication of the international application, reference is made to INID codes (15), (48) or (88) (*as the case may be*) on the front page of the published international application.

A copy of the international application is available for viewing and downloading on WIPO's website at the following address: www.wipo.int/pctdb (in the appropriate field of the structured search, enter the PCT or WO number).

The applicant may also obtain a paper copy of the published international application from the International Bureau by sending an e-mail to patentscope@wipo.int or by submitting a written request to the contact details provided below.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 82 70

Authorized officer
Philippe Bécamel

e-mail: pt01.pct@wipo.int

Form PCT/IB/311 (January 2009)

특허협력조약

발신: 국제조사기관

수신:
김 은구

서울특별시 강남구 역삼동 636-15 상원빌딩 2층 135-908
대한민국

PCT

국제조사기관의 견해서

(PCT규칙 43의2.1)

발송일 *(일/월/년)*	**2011년 12월 28일 (28.12.2011)**
출원인 또는 대리인의 서류참조기호 PCT11-354	**추가적인 조치** 아래 2를 참조

국제출원번호	국제출원일 *(일/월/년)*	우선일 *(일/월/년)*
PCT/KR2011/004835	**2011년 07월 01일 (01.07.2011)**	2010년 07월 05일 (05.07.2010)

국제특허분류(IPC)

H04B 7/04(2006.01)i

출원인

(주)팬택 등

1. 본 견해서는 다음 기재란에 관한 내용을 포함합니다.
   - ☒ 제1기재란 견해서의 기초
   - ☐ 제2기재란 우선권
   - ☐ 제3기재란 신규성, 진보성 및 산업상이용가능성에 관한 견해 부작성
   - ☐ 제4기재란 발명의 단일성 결여
   - ☒ 제5기재란 신규성, 진보성 또는 산업상이용가능성에 관한 견해(PCT규칙 43의2.1(a)(i)), 이를 뒷받침하는 인용문헌 및 설명
   - ☒ 제6기재란 특이 인용문헌
   - ☒ 제7기재란 국제출원의 흠결
   - ☒ 제8기재란 국제출원에 관한 의견

2. **추가적인 조치**

국제예비심사가 청구되면, 본 견해서는 국제예비심사기관("IPEA")의 견해서로 간주될 것입니다. 다만, 출원인이 본 기관 이외의 기관을 IPEA로 선택하고, 그 선택된 IPEA가 PCT규칙 66.1의2(b)에 따라 본 국제조사기관의 견해서가 위와 같이 간주되지 않을 것임을 국제사무국에 통보한 경우에는 그러하지 않습니다.

본 견해서가 상기와 같이 IPEA의 견해서로 간주되는 경우, 출원인은 서식 PCT/ISA/220의 발송일로부터 3월 또는 우선일부터 22월 중 늦게 만료되는 날 이전에 의견서 및 보정서(해당하는 경우)를 IPEA에 제출할 수 있습니다.

다른 선택사항에 대하여는 서식 PCT/ISA/220에 대한 안내문을 참조하십시오.

ISA/KR의 명칭 및 우편주소	본 견해서의 완료일	심사관
대한민국 특허청 (302-701) 대전광역시 서구 청사로 189, 정부대전청사 팩스번호 82-42-472-7140	2011년 12월 28일 (28.12.2011)	김병성 전화번호 82-42-481-5652

서식 PCT/ISA/237 (표지) (2011년 7월)

국제조사기관의 견해서

국제출원번호
PCT/KR2011/004835

제1기재란 본 견해서의 기초

1. **언어**와 관련하여, 본 견해서는 아래에 기초하여 작성되었습니다.

   ☒ 출원시의 언어로 된 국제출원

   ☐ 국제조사를 위하여 _____ 로 번역되어 제출된 국제출원의 번역문
   (PCT규칙 12.3(a) 및 23.1(b))

2. ☐ 본 견해서는 PCT규칙 91에 따라 당해 기관이 허가하였거나 당해 기관에 통보된 **명백한 잘못의 정정**을 고려하여 작성되었습니다(PCT규칙 43의2.1(a)).

3. 국제출원에 개시된 **핵산염기 서열 및/또는 아미노산 서열**과 관련하여, 본 견해서는 아래에 기초하여 작성되었습니다.

   a. 출원시 또는 추후 제출된 서열목록
   ☐ 서면
   ☐ 전자적 형태

   b. 제출시기
   ☐ 출원시 국제출원에 포함
   ☐ 국제출원과 함께 전자적 형태로 제출
   ☐ 조사를 위해 본 기관에 추후 제출

4. ☐ 추가로 서열목록에 대하여 하나 이상의 버전이나 사본이 제출된 경우, 후속 버전 또는 추가된 사본에 기재되어 있는 정보가 출원시의 정보와 동일하거나 또는 출원시의 개시범위를 벗어나지 않는다는 진술서가 제출되었습니다.

5. 추가 의견:

국제조사기관의 견해서

국제출원번호
PCT/KR2011/004835

제5기재란 신규성, 진보성 또는 산업상이용가능성에 관한 견해(PCT규칙 43의2.1(a)(i)), 이를 뒷받침하는 인용문헌 및 설명

1. 견해

신규성 (N)	청구항	1-31	있음
	청구항	없음	없음
진보성 (IS)	청구항	1-31	있음
	청구항	없음	없음
산업상 이용가능성 (IA)	청구항	1-31	있음
	청구항	없음	없음

2. 인용문헌 및 설명:

참고한 인용문헌은 다음과 같습니다.

D1: US 2010-0048233 A1 (KIM YU-SEOK 외 4명) 2010.02.25
D2: WO 2009-125956 A1 (LG ELECTRONICS INC. 외 6명) 2009.10.15

신규성 및 진보성

이 출원은 송수신단 모두에서 다중입력다중출력(MIMO) 안테나를 이용하는 무선통신시스템에 관한 것입니다. 독립 청구항 1항은 제1프리코더와 제2프리코더를 포함하는 송신장치의 통신방법을 청구하고 있고, (a1) 자신의 코드북에서 각 레이어에 대해 상기 제1프리코더의 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코더의 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 각각 결정하는 단계 및 (b1) 결정한 상기 제1정보와 상기 제2정보 중 적어도 하나를 포함하는 코드북제한정보를 수신장치에 전송하는 단계를 기술적 특징으로 포함하고 있습니다.

인용문헌 D1 및 D2는 MIMO를 이용하는 무선통신시스템에서 프리코딩 정보를 전송하거나 코드북을 이용하여 채널정보를 전송하는 구성을 기재하고는 있으나, 상기 1항의 구성 (a1) 및 (b1)에 관해서는 개시하거나 암시하지 않고 있습니다. 또한, 상기 1항의 기술적 특징은 통상의 기술자가 D1, D2 또는 D1과 D2의 조합에 의해서도 쉽게 도출해낼 수 없습니다. 따라서, 상기 1항은 신규성 및 진보성이 있습니다(PCT 제33조(2),(3)).

독립 청구항 10, 18 및 25항은 송신장치, 수신장치의 통신방법 및 수신장치를 청구하고 있습니다. 상기 10, 18 및 25항의 각 기능 내지 단계는 청구항 1항의 각 단계에 단순히 대응하는 정도로, 상기 10, 18 및 25항은 1항의 방법에 기반한 이 출원의 또다른 발명의 형태입니다. 따라서, 상기 10, 18 및 25항은 신규성 및 진보성이 있습니다(PCT 제33조(2),(3)).

청구항 2~9, 11~17, 19~24 및 26~31항은 1, 10, 18 또는 25항을 인용하는 종속항이므로 신규성 및 진보성이 있습니다(PCT 제33조(2),(3)).

산업상 이용가능성

청구항 1~31항은 PCT 제33조(4)에 비추어 산업상 이용가능성이 있습니다.

국제조사기관의 견해서

국제출원번호
PCT/KR2011/004835

제6기재란 특이 인용문헌

1. 특이 공개문헌 (PCT규칙 43의2.1 및 70.10)

	출원번호 특허번호	공개일 *(일/월/년)*	출원일 *(일/월/년)*	우선일(유효한 우선권주장) *(일/월/년)*
P,X	US 12/777,787	19/05/2011	11/05/2010	16/11/2009

특허출원 US 12/777,787 (공개특허 US 2011-0116563 A1)은 PCT 규칙 64.3의 관점에서 선행기술을 구성하지 아니하지만, 청구항 1, 10, 18 및 25항의 모든 기술적 특징을 포함하고 있습니다. 본 출원의 우선권주장이 유효하지 않은 경우, 이 문헌은 신규성 및 진보성을 판단하는 데에 이용될 수 있습니다.

2. 비서면에 의한 개시 (PCT규칙 43의2.1 및 70.9)

비서면에 의한 개시의 종류	비서면에 의한 개시일 *(일/월/년)*	비서면에 의한 개시를 언급하고 있는 서면의 개시일 *(일/월/년)*

국제조사기관의 견해서

국제출원번호

PCT/KR2011/004835

제7기재란 국제출원의 흠결

국제출원의 기재 형식 또는 내용에 다음과 같은 결함이 발견되었습니다.

1) 이 출원의 '도면의 간단한 설명'은 도8, 도9 및 도10에 관한 설명을 누락하고 있습니다(PCT 조약규칙 5.1(iv)).

국제조사기관의 견해서

국제출원번호

PCT/KR2011/004835

제8기재란 국제출원에 관한 의견

청구범위, 명세서 및 도면의 명료성에 관하여 또는 청구범위가 명세서에 의하여 충분히 뒷받침되고 있는지에 관하여 다음과 같은 의견을 제시합니다.

1) 청구항 25항의 '제2프리코딩 행렬로 사용되는 것을 제한하는 제1정보'에서 '제1정보'는 '제2정보'로 수정되어야 합니다 (PCT 조약 제6조).

특허협력조약
PCT

국제조사보고서
(PCT 제 18 조 및 PCT규칙 43 및 44)

출원인 또는 대리인의 서류참조기호 PCT11-354	추가적인 조치	서식 PCT/ISA/220 및 아래 5.(해당하는경우) 참조
국제출원번호 **PCT/KR2011/004835**	국제출원일 (일/월/년) **2011년 07월 01일 (01.07.2011)**	(최) 우선일 (일/월/년) 2010년 07월 05일 (05.07.2010)

출원인

(주)팬택 등

본 국제조사보고서는 본 국제조사기관에 의하여 작성되었으며 PCT 제18조의 규정에 따라 출원인에게 송부됩니다. 이 국제조사보고서의 사본은 국제사무국에 송부됩니다.

본 국제조사보고서는 총 **4** 매로 구성되어 있습니다.

☐ 본 보고서에서 인용된 각 선행기술 문헌의 사본도 첨부되어 있습니다.

1. **보고서의 기초**
   a. **언어**와 관련하여, 국제조사는 아래에 기초하여 수행되었습니다.
      ☒ 출원시의 언어로 된 국제출원
      ☐ 국제조사를 위해 _____ 로 번역되어 제출된 국제출원의 번역문(PCT규칙 12.3(a) 및 23.1(b))
   b. ☐ 본 국제조사보고서는 PCT규칙 91의 규정에 따라 당해 기관이 허가하였거나 또는 당해 기관에 통보된 **명백한 잘못의 정정**을 고려하여 작성되었습니다(PCT규칙 43.6의2(a)).
   c. ☐ 국제출원에 개시된 **핵산염기 및/또는 아미노산 서열**에 관하여는 제1기재란을 참조하십시오.
2. ☐ **일부 청구항은 조사할 수 없습니다**(제2기재란 참조).
3. ☐ **발명의 단일성이 결여되어 있습니다**(제3기재란 참조).
4. **발명의 명칭**과 관련하여,
   ☒ 출원인이 제출한 대로 승인합니다.
   ☐ 본 국제조사기관이 다음과 같이 발명의 명칭을 작성하였습니다:
5. **요약서**와 관련하여,
   ☐ 출원인이 제출한 대로 승인합니다.
   ☒ PCT규칙 38.2의 규정에 따라 본 기관이 제4기재란에 표시된 대로 요약서를 작성하였습니다. 출원인은 본 국제조사보고서의 발송일부터 1월 이내에 본 기관에 의견를 제출할 수 있습니다.
6. **도면**과 관련하여,
   a. 요약서와 함께 공개될 **도면**은 제 **3** 도이며
      ☒ 출원인이 제안하였습니다.
      ☐ 출원인이 도면의 번호를 제안하지 않았기 때문에 본 기관이 선택하였습니다.
      ☐ 본 도면이 발명의 특징을 더 잘 나타내고 있기 때문에 본 기관이 선택하였습니다.
   b. ☐ 요약서와 함께 공개될 도면이 없습니다.

제4기재란 요약서의 내용(첫 번째 용지의 5의 계속)

이 출원은 송수신단 모두에서 다중입력다중출력(MIMO) 안테나를 이용하는 무선통신시스템에 관한 것이다. 특히, 제1프리코더와 제2프리코더를 포함하는 송신장치에서 자신의 코드북에서 각 레이어에 대해 상기 제1프리코더의 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코더의 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 각각 결정하는 단계 및 결정한 상기 제1정보와 상기 제2정보 중 적어도 하나를 포함하는 코드북제한정보를 수신장치에 전송하는 단계를 기술적 특징으로 포함하고 있다.

국 제 조 사 보 고 서

국제출원번호
PCT/KR2011/004835

A. 발명이 속하는 기술분류(국제특허분류(IPC))

H04B 7/04(2006.01)i

B. 조사된 분야

조사된 최소문헌(국제특허분류를 기재)
H04B 7/04; H04L 27/28; H04B 15/00

조사된 기술분야에 속하는 최소문헌 이외의 문헌
한국등록실용신안공보 및 한국공개실용신안공보: 조사된 최소문헌란에 기재된 IPC
일본등록실용신안공보 및 일본공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

국제조사에 이용된 전산 데이터베이스(데이터베이스의 명칭 및 검색어(해당하는 경우))
eKOMPASS(특허청 내부 검색시스템) & 키워드: 코드북, 제한, 프리코더, 무선통신

C. 관련 문헌

카테고리*	인용문헌명 및 관련 구절(해당하는 경우)의 기재	관련 청구항
A	US 2010-0048233 A1 (KIM YU-SEOK 외 4명) 2010.02.25 요약, 문단 [50] - 문단 [52] 및 도 6 참조.	1-31
A	WO 2009-125956 A1 (LG ELECTRONICS INC. 외 6명) 2009.10.15 요약 및 청구항 1항 참조.	1-31
PX PA	US 2011-0116563 A1 (VITTHALADEVUNI PAVAN KUMAR 외 2명) 2011.05.19 요약, 문단 [78] - 문단 [79] 및 도 19,20 참조.	1,10,18,25 2-9,11-17,19-24 ,26-31

☐ 추가 문헌이 C(계속)에 기재되어 있습니다.

☒ 대응특허에 관한 별지를 참조하십시오.

* 인용된 문헌의 특별 카테고리:

"A" 특별히 관련이 없는 것으로 보이는 일반적인 기술수준을 정의한 문헌

"E" 국제출원일보다 빠른 출원일 또는 우선일을 가지나 국제출원일 이후에 공개된 선출원 또는 특허 문헌

"L" 우선권 주장에 의문을 제기하는 문헌 또는 다른 인용문헌의 공개일 또는 다른 특별한 이유(이유를 명시)를 밝히기 위하여 인용된 문헌

"O" 구두 개시, 사용, 전시 또는 기타 수단을 언급하고 있는 문헌

"P" 우선일 이후에 공개되었으나 국제출원일 이전에 공개된 문헌

"T" 국제출원일 또는 우선일 후에 공개된 문헌으로, 출원과 상충하지 않으며 발명의 기초가 되는 원리나 이론을 이해하기 위해 인용된 문헌

"X" 특별한 관련이 있는 문헌. 해당 문헌 하나만으로 청구된 발명의 신규성 또는 진보성이 없는 것으로 본다.

"Y" 특별한 관련이 있는 문헌. 해당 문헌이 하나 이상의 다른 문헌과 조합하는 경우로 그 조합이 당업자에게 자명한 경우 청구된 발명은 진보성이 없는 것으로 본다.

"&" 동일한 대응특허문헌에 속하는 문헌

국제조사의 실제 완료일	국제조사보고서 발송일
2011년 12월 28일 (28.12.2011)	**2011년 12월 28일 (28.12.2011)**

ISA/KR의 명칭 및 우편주소
대한민국 특허청
(302-701) 대전광역시 서구 청사로 189,
정부대전청사
팩스 번호 82-42-472-7140

심사관
김병성

전화번호 82-42-481-5652

서식 PCT/ISA/210 (두 번째 용지) (2009년 7월)

국제조사보고서
대응특허에 관한 정보

국제출원번호
PCT/KR2011/004835

국제조사보고서에서 인용된 특허문헌	공개일	대응특허문헌	공개일
US 2010-0048233 A1	2010.02.25	KR 10-2010-0023529 A	2010.03.04
WO 2009-125956 A1	2009.10.15	CN 101981823 A	2011.02.23
		CN 101981824 A	2011.02.23
		CN 101981825 A	2011.02.23
		EP 2245758 A1	2010.11.03
		EP 2248277 A1	2010.11.10
		EP 2248278 A1	2010.11.10
		EP 2340620 A2	2011.07.06
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		JP 2011-518491 A	2011.06.23
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		KR 10-2009-0106975 A	2009.10.12
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		US 2009-0257383 A1	2009.10.15
		US 2009-0257384 A1	2009.10.15
		US 2009-0268698 A1	2009.10.29
		US 2010-0118997 A1	2010.05.13
		US 8045528 B2	2011.10.25
		WO 2009-125954 A1	2009.10.15
		WO 2009-125955 A1	2009.10.15
		WO 2010-050689 A2	2010.05.06
US 2011-0116563 A1	2011.05.19	WO 2011-060299 A2	2011.05.19
		WO 2011-060299 A3	2011.08.25

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2011/004835

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 7/04; H04L 27/28; H04B 15/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

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

eKOMPASS (KIPO internal) & Keywords: code book, restriction, precoder, wireless communication

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010-0048233 A1 (KIM, YU-SEOK et al.) 25 February 2010 See abstract, paragraph [50] - paragraph [52] and figure 6.	1-31
A	WO 2009-125956 A1 (LG ELECTRONICS INC. et al.) 15 October 2009 See abstract and claim 1.	1-31
PX PA	US 2011-0116563 A1 (VITTHALADEVUNI PAVAN KUMAR et al.) 19 May 2011 See abstract, paragraph [78] - paragraph [79] and figures 19,20.	1,10,18,25 2-9,11-17,19-24 ,26-31

☐ 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	Date of mailing of the international search report
28 DECEMBER2011 (28.12.2011)	**28 DECEMBER2011 (28.12.2011)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

Patent document cited in search report	Publication date	Patent family member	Publication date
US 2010-0048233 A1	25.02.2010	KR 10-2010-0023529 A	04.03.2010
WO 2009-125956 A1	15.10.2009	CN 101981823 A	23.02.2011
		CN 101981824 A	23.02.2011
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		EP 2245758 A1	03.11.2010
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		KR 10-2009-0106975 A	12.10.2009
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		US 2009-0257383 A1	15.10.2009
		US 2009-0257384 A1	15.10.2009
		US 2009-0268698 A1	29.10.2009
		US 2010-0118997 A1	13.05.2010
		US 8045528 B2	25.10.2011
		WO 2009-125954 A1	15.10.2009
		WO 2009-125955 A1	15.10.2009
		WO 2010-050689 A2	06.05.2010
US 2011-0116563 A1	19.05.2011	WO 2011-060299 A2	19.05.2011
		WO 2011-060299 A3	25.08.2011

특 허 협 력 조 약
(PATENT COOPERATION TREATY)

발신 : 국제조사기관

수신 :
김 은구

서울특별시 강남구 역삼동 636-15 상원빌딩 2층
135-908 대한민국

PCT

**국제조사보고서 및 국제조사기관의 견해서,
또는 국제조사보고서
부작성 선언서 송부 통지서
(PCT 규칙 44.1)**

발송일 (일/월/년)	2011년 12월 28일 (28.12.2011)
출원인 또는 대리인 서류참조기호 PCT11-354	**이후의 절차에 대하여는** 아래 1. 및 4. 참조
국제출원번호 **PCT/KR2011/004835**	국제출원일 (일/월/년) **2011년 07월 01일 (01.07.2011)**
출원인 **(주)팬택 등**	

1. ☒ 국제보고서 및 국제조사기관의 견해서가 작성되어 이를 송부함을 출원인에게 통지합니다.
조약 제19조의 규정에 의한 보정서 및 설명서의 제출:
희망하는 경우 출원인은 국제출원의 청구의 범위를 보정할 수 있습니다.(조약규칙 46):
기간 보정서 제출기간은 통상 국제조사보고서 송부일부터 2월.

제출처 International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Faxcimile No. : +41 22 338 82 70

보다 자세한 지침에 대하여는 *PCT 출원인안내*의 국제단계 9.004-9.011 단락을 참조.

2. ☐ 국제조사보고서가 작성되지 아니할 것이며 조약 제17조(2)(a)의 규정에 의한 선언서 및 국제조사기관의 견해서가 송부됨을 출원인에게 통지합니다.

3. ☐ 조약규칙 40.2의 규정에 의한 추가수수료 납부에 대한 **이의신청과 관련하여** 아래 사항을 출원인에게 통지합니다.
☐ 이의신청 및 이의신청에 대한 결정 통지서를 지정관청에 송부하여 줄 것을 요청하는 신청서와 함께 이의신청 및 이의신청 결정 통지서를 국제사무국에 송부하였습니다.
☐ 이의신청에 대한 결정이 아직 이루어지지 않았습니다: 결정이 이루어지는 대로 출원인에게 통지할 것입니다.

4. **주의사항**
출원인은 비공식적으로 국제조사기관의 견해서에 대한 의견서를 국제사무국에 제출할 수 있다. 국제사무국은 국제예비심사보고서가 작성되지 아니했거나 작성되지 아니할 예정인 경우 당해 의견서의 사본을 모든 지정관청에 송부할것이다. 당해 의견서는 공중에 이용가능하게 될 것이나, 우선일부터 30월 만료 후에, 당해 의견서는 공중에 이용가능하게 될 것입니다.

우선일부터 **18월** 만료직후 국제사무국은 국제출원을 공개합니다. 공개를 하지 않거나 또는 연기할 것을 희망하는 경우에는 출원인은 국제공개의 기술적 준비가 완료되기 전에 국제사무국에 제출하여야 합니다. 국제출원 취하서 또는 우선권주장 취하서를 국제사무국에 제출하여야 합니다(조약 규칙 90*bis*.1 및 90*bis*.3).

일부 지정관청에 대하여는 출원인이 우선일부터 **30월까지** (일부관청에 대하여는 더 늦을수도 있음) 국내단계의 개시를 연기하고자 하는 경우에는 우선일부터 **19월**이내에 국제예비심사를 청구하여야 합니다; 그렇지 않은 경우 출원인은 우선일부터 **20월 이내에** 당해 지정관청에 대한 국내단계의 개시를 위한 규정된 절차를 밟아야 합니다.

다른 지정관청에 대하여는, 우선일부터 19월 이내에 국제예비심사를 청구하지 않더라도 30월(또는 더 늦을 수도 있음)의 기간이 적용될 것입니다.

각 특허청마다의 적용기간에 대한 구체적인 사항은 www.wipo.int/pct/en/texts/time_limits.html 및 *PCT출원인안내*의 국내단계를 참조하시기 바랍니다.

ISA/KR의 명칭 및 우편주소
대한민국 특허청
(302-701) 대전광역시 서구 청사로 189,
정부대전청사

팩스 번호 82-42-472-7140

특허청장

전화번호 82-42-481-8753

* 참고사항

국제조사보고서에 인용된 문헌의 사본은 아래 특허청 영문홈페이지를 통해 국제조사보고서 발송일부터 3개월간 다운로드 할 수 있습니다.

http://www.kipo.go.kr/en/ => Patent Search => PCT-Service

ID : PCT 국제출원번호 (예: PCT/KR2008/012345)
PW : **25DQBWYD**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:	Docket No.: P5158US00
Kyoungmin PARK	
Serial No.: To be assigned	Group Art Unit: To be assigned
Confirmation No.: To be assigned	
Filed: Currently herewith	Examiner: To be assigned

For: **TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH**

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PRELIMINARY AMENDMENT

Sir:

Prior to examination on the merits, please amend the above-identified application as follows.

Amendment to the Specification begins on page 2.

Remarks begin on page 3.

No extensions of time are required at this time. If extensions of time are necessary to prevent abandonment of this application, then they are petitioned for under 37 C.F.R. § 1.136(a). No fees for net addition of claims are required at this time. Any fees required for extensions of time or for the net addition of claims may be charged to our Deposit Account No. 50-3698.

AMENDMENT TO THE SPECIFICATION

In the Specification:

Please replace the specification with the attached substitute specification. A version with markings and a clean version are attached. The claims are not included with the substitute specification.

The substitute specification does not contain new matter.

REMARKS

Claims have been amended to amend informalities. Accordingly, claims 1-31 are currently pending in the application, of which claim 1, 10, 18, and 25 are independent. The specification has been amended to correct certain informalities.

Applicants respectfully submit that the amendments do not add new matter to the application.

If the Examiner believes, for any reason, that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at the number provided.

Prompt and favorable consideration of this Amendment is respectfully requested.

Respectfully submitted,

/hae-chan park/

Hae-Chan Park
Reg. No. 50,114

Date: December 28, 2012

CUSTOMER NUMBER: 58027
H.C. Park & Associates, PLC
1894 Preston White Drive
Reston, VA 20191
Tel: 703-288-5105
Fax: 703-288-5139
HCP/SKH/cel

Attachments: (1) Substitute Specification, marked-up copy
(2) Substitute Specification, clean copy

~~Description~~

~~Title of Invention:~~ TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

~~[1]~~

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is the National Stage Entry of International Application No. PCT/KR2011/004835, filed on July 1, 2011, and claims priority from and the benefit of Korean Patent Application No. 10-2010-0064573, filed on July 5, 2010, all of which are hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND

[0002] ~~Technical Field~~FIELD

~~[2]~~**[0003]** The present invention relates to a wireless communication system, and more particularly, to a wireless communication system that uses multiple input multiple output (MIMO) in both a transmitting end and a receiving end.

[0004] ~~Background Art~~DISCUSSION OF THE BACKGROUND

~~[3]~~**[0005]** As communication systems have developed, various wireless terminals have been utilized by consumers, such as companies and individuals.

~~[4]~~**[0006]** A current mobile communication system, such as 3GPP, LTE (Long Term Evolution), LTE-A (LTE Advanced), and the like, may be a high capacity communication system capable of transmitting and receiving various data such as image data, wireless data, and the like, beyond providing a sound-based service. Accordingly, there is a desire for a technology that transmits high capacity data, which is comparable with a wired communication network. Also, the system is required to minimize loss of information and increase transmission efficiency of the system so as to enhance performance of the system.

~~Detailed Description of the Invention~~

~~Technical Solution~~ SUMMARY

~~[5]~~**[0007]** In accordance with an aspect of the present invention, there is provided a communication method of a transmitting device including a first precoder and a second precoder, the method including: determining first information to restrict a precoding matrix from being used as a first precoding matrix of the first precoder, and second information to restrict a precoding matrix from being used as a second precoding matrix of the second precoder in a corresponding codebook with respect to each layer; and transmitting, to a receiving device, codebook restricting information including at least one of the determined first information and

second information.

~~[6]~~**[0008]** In accordance with another aspect of the present invention, there is provided a transmitting device, the device including: a layer mapper to map a codeword to a layer; a precoder including a first precoder and a second precoder that performs precoding on a data symbol corresponding to the codeword mapped to the layer by the layer mapper, using a first precoding matrix and a second precoding matrix selected from a corresponding codebook; and an antenna array to transmit signals output from the precoder, and the codeword includes at least one of first information to restrict a precoding matrix from being used as the first precoding matrix and second information to restrict a precoding matrix from being used as the second precoding matrix in the corresponding codebook with respect to each layer.

~~[7]~~**[0009]** In accordance with another aspect of the present invention, there is provided a communication method of a receiving device in a wireless communication system, the method including: receiving codebook restricting information including at least one of first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix for each layer; and transmitting, to a transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix being selected, based on the codebook restricting information, from among precoding matrices that are not restricted from being used as

the first precoding matrix or the second precoding matrix in a codebook.

~~[8]~~**[0010]** In accordance with another aspect of the present invention, there is provided a receiving device in a wireless communication system, the device including: an antenna array to receive, as codebook restricting information, at least one of first information to restrict a precoding matrix from being used as a first precoding matrix and first information to restrict a precoding matrix from being used as a second precoding matrix with respect to each layer; and a channel information feedback device to transmit, to a transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix being selected, based on the codebook restricting information, from among precoding matrices that are not restricted from being used as the first precoding matrix of the second precoding matrix in a codebook.

~~Brief Description of the Drawings~~BRIEF DESCRIPTION OF THE DRAWINGS

~~[9]~~**[0011]** FIG. 1 is a block diagram illustrating a wireless communication system according to embodiments of the present invention;

~~[10]~~**[0012]** FIG. 2 is a diagram illustrating a wireless communication system in which a base station and a user equipment exchange codebook restricting information and channel status information in a case of codebook restriction;

~~[11]~~**[0013]** FIG. 3 is a flowchart further illustrating a reference signal and signal transmission in the wireless communication system that exchanges codebook restricting information and channel status information of FIG. 2;

~~[12]~~**[0014]** FIG. 4 is a block diagram illustrating a base station and a user equipment in a MIMO wireless communication system according to an embodiment of the present invention;

~~[13]~~**[0015]** FIG. 5 is a diagram illustrating a channel between a base station and a user equipment that use a polarized antenna array of FIG. 4;

~~[14]~~**[0016]** FIG. 6 is a flowchart illustrating a communication method of a transmitting device according to another embodiment of the present invention; and

[0017] FIG. 7 is a flowchart illustrating a communication method of a receiving device according to another embodiment of the present invention.

~~[15]~~**[0018]** FIGS. 8 through 10 are conceptual diagrams illustrating a process of controlling inter-cell interference using a codebook restriction scheme in a wireless communication system according to embodiments of the present invention.

~~Mode for Carrying Out the Invention~~DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

~~[16]~~**[0019]** Hereinafter, exemplary embodiments of the present invention will be

described with reference to the accompanying drawings. In the following description, the same elements will be designated by the same reference numerals although they are shown in different drawings. Further, in the following description of the present invention, a detailed description of known functions and configurations incorporated herein will be omitted when it may make the subject matter of the present invention rather unclear.

~~[17]~~**[0020]** FIG. 1 is a block diagram illustrating a wireless communication system according to embodiments of the present invention.

~~[18]~~**[0021]** The wireless communication system may be widely installed so as to provide various communication services such as voice data, packet data, and the like.

~~[19]~~**[0022]** Referring to FIG. 1, the wireless communication system may include a user equipment (UE) 10 and a base station (BS) 20.

~~[20]~~**[0023]** The user equipment 10 may be an inclusive concept indicating a user terminal utilized in a wireless communication, including a UE (User Equipment) in WCDMA, LTE, HSPA, and the like, and an MS (Mobile Station), a UT (User Terminal), an SS (Subscriber Station), a wireless device and the like in GSM.

~~[21]~~**[0024]** The base station 20 or a cell may generally refer to a station where communication with the user equipment 10 is performed, and may also be referred to as a Node-B, an eNB (evolved Node-B), a BTS (Base Transceiver System), an access point, a relay node, and the like.

~~[22]~~**[0025]** In the specifications, the user equipment 10 and the base station 20 are used as two inclusive transceiving subjects to embody the technology and technical concepts described in the specifications, and may not be limited to a predetermined term or word.

~~[23]~~**[0026]** An embodiment of the present invention may be applicable to an asynchronous wireless communication scheme that is advanced through GSM, WCDMA, and HSPA, to be LTE (Long Term Evolution) and LTE-advanced, and may be applicable to a synchronous wireless communication scheme that is advanced through CDMA and CDMA-2000, to be UMB. Embodiments of the present invention may not be limited to a specific wireless communication scheme, and may be applicable to all technical fields to which a technical idea of the present invention is applicable.

~~[24]~~**[0027]** The wireless communication system according to embodiments of the present invention may support an uplink and/or downlink HARQ (Hybrid Automatic Repeat request), and may use a CQI (channel quality indicator) for link adaptation. Also, a multiple access scheme for downlink transmission and a multiple access scheme for uplink transmission may be different from each other. For example, a downlink may use OFMDA (Orthogonal Frequency Division Multiple Access) and an uplink may use SC-FDMA (Single Carrier-Frequency Division Multiple Access).

~~[25]~~**[0028]** To support high-speed information transmission for the user, the wireless communication system may consider using a Multiple Input Multiple Output (MIMO)

scheme that transfers information through the same band using an antenna array including a multi-antenna.

~~[26]~~**[0029]** To embody an effective MIMO system, a MIMO wireless communication system may need to provide, to a transmitting device, information associated with a propagation channel or information associated with a precoder or a precoding matrix (hereinafter referred to as a precoding matrix) appropriate for a propagation channel, to increase transmission capacity. In this example, the former requires a large amount of feedback overhead, whereas the latter requires a relatively small amount of feedback overhead.

~~[27]~~**[0030]** In the latter case, each of the user equipment 10 and the base station 20 stores a codebook that defines N available precoding matrices, and expresses an index or an indicator indicating or indexing (corresponding to) each precoding matrix, and identification. Each user equipment 10 selects a precoding matrix appropriate for a propagation channel, and transmits an index indexing the selected precoding matrix to the base station 20. The base station 20 receives precoding matrix indices from each user equipment 10, and selects a MIMO mode or a user equipment or performs precoding based on the received precoding matrix indices.

~~[28]~~**[0031]** In this example, as a size of a codebook becomes larger since a number of available precoding matrices is large, the precoding performance of the base station 120 increases. However, an amount of feedback overhead of the user equipment 10 required for reporting the precoding matrices or corresponding indices to the base station 20 may be

increased. Therefore, when a large size codebook is used, a codebook restriction or a codebook subset restriction that restricts at least one precoding matrix in a codebook may need to be used for more effective precoding.

~~[29]~~**[0032]** The codebook restriction is a scheme that generates a codebook including various precoding matrices, selects a precoding matrix to be used/not used in the codebook for each cell or each user equipment, and uses different codebooks for each cell or each user equipment based on codebook restricting information (hereinafter referred to as "codebook restricting information") associated with a precoding matrix to be not used. When the codebook restriction scheme is used, the whole wireless communication system has a large size codebook, but a codebook that is used by each cell or each user equipment is configured of subsets of the codebook, and has a small size, and is configured of only precoding matrices appropriate for a given environment and thus, a precoding gain may be increased.

~~[30]~~**[0033]** For example, when downlink MIMO transmission between the base station 20 and the user equipment 10 simultaneously performs transmission with respect to up to 4 layers, the user equipment 10 may transfer, to the base station 20 using a rank indicator (RI), a number of layers that the user equipment 10 is capable of receiving. In this example, 16 precoding matrices may be designated for each rank during the downlink MIMO transmission between the base station 20 and the user equipment 10, and a total of 64 precoding matrices may be configured as shown in Table 1.

~~[31]~~**[0034]** ~~[Table 1]~~Table 1

~~[32]~~

RI \ PMI	0	1	2	·····	15
1	a0	a1	a2	·····	a15
2	a16	a17	a18	·····	a31
3	a32	a33	a34	·····	a47
4	a48	a49	a50	·····	a63

~~[33]~~**[0035]** In a case in which the codebook restriction is used, when whether a precoding matrix is to be used is determined for each of the 64 precoding matrices and codebook restricting information is transmitted based on a bitmap format that designates whether each precoding matrix is to be used using 1 bit, a total of 64 bits may be required. For example, a corresponding order of an available precoding matrix is expressed to be 1, and a corresponding order of an unavailable precoding matrix is expressed to be 0, as shown in [001010010……010].

~~[34]~~**[0036]** The user equipment 10 may report, to the base station 20 as channel status information, 64 indices corresponding to the total of 64 precoding matrices using a total of 6 bits. In this example, when a codebook restriction that restricts the use of 32 precoding matrices from among the 64 precoding matrices is used, a number of information to be distinguished by 6 bits may be decreased from 64 to 32 and thus, a degree of reliability of a

feedback signal may be increased. The user equipment 10 may decrease a number of bits that expresses the indices corresponding to the precoding matrices to 5 bits so as to reduce an amount of feedback overhead of the channel status information.

~~[35]~~**[0037]** In addition, the use of precoding matrices that are predicted to cause inter-cell interference may be restricted by the codebook restriction and thus, the inter-cell interference may be prevented in advance. In particular, when a beamforming like precoding that is based on a location of each user equipment is performed, a user equipment located in a cell edge may cause serious inter-cell interference. To prevent the inter-cell interference in advance, a codebook restriction may be performed for each cell and thus, the inter-cell interference may be controlled.

~~[36]~~**[0038]** The base station 20 may use a multistage precoder including at least two precoders. The codebook restriction that restricts a precoding matrix to be used for each precoder may also be applicable, when the multistage precoder is used. In this example, a number of precoding matrices is generally increased and a number of bits to be used for codebook restricting information for the codebook restriction may also be increased.

~~[37]~~**[0039]** In particular, a high signaling and feedback overhead may be required to support high speed information transmission in an uplink or a downlink and thus, a number of bits that the base station 20 uses to inform each user equipment 10 of the codebook restriction may need to be reduced.

~~[38]~~**[0040]** The wireless communication system according to embodiments of the present invention has been described. Hereinafter, with reference to FIGS. 2 and 3, a process will be described in which a base station and a user equipment exchange codebook restricting information and channel status information in a wireless communication system when a multistage precoder is used in a case of codebook restriction.

~~[39]~~**[0041]** FIG. 2 illustrates a wireless communication system in which a base station and a user equipment exchange codebook restricting information and channel status information in a case of codebook restriction.

~~[40]~~**[0042]** Referring to FIG. 2, a wireless communication system 100 may include the base station 120 and may include at least one user equipment existing in the wireless communication system 100, for example, n user equipments 110, like the wireless communication system of FIG. 1. Although the user equipments 110 may correspond to user equipments that are currently being connected or that attempt additional connection, a single user equipment is illustrated in FIG. 2 for ease of descriptions.

~~[41]~~**[0043]** The base station 120 includes a multistage precoder including at least two precoders, that is, first and second precoders. The base station 120 stores a first codebook 122 that expresses N first precoding matrices to be used for the first precoder and first indices indexing the first precoding matrices and a second codebook 124 that expresses M second precoding matrices to be used for the second precoder and second indices indexing the second

precoding matrices.

~~[42]~~**[0044]** The base station stores a restriction book 126 including ranks and an index (hereinafter referred to as a restriction index) corresponding to each pair of a first index and a second index with respect to each rank. The base station 120 determines a precoding matrix to be used/not used for each cell or for each user equipment, and may transmit, to the user equipment 110, codebook restricting information 128 associated with the precoding matrix to be not used. In this example, the codebook restricting information 128 includes first information that restricts a precoding matrix from being used as a first precoding matrix and second information that restricts a precoding matrix from being used as a second precoding matrix in the first and second codebooks 122 and 124 with respect to each layer.

~~[43]~~**[0045]** FIG. 3 is a flowchart further illustrating a reference signal and signal transmission in the wireless communication system that exchanges codebook restricting information and channel status information of FIG. 2.

~~[44]~~**[0046]** Referring to FIG. 3, for transmission and reception of data between the user equipment 110 and the base station 120, the base station 120 at a transmitter side transmits a reference signal 130 as further illustrated in FIG. 3, and the user equipment 110 at a receiver side estimates a channel using the reference signal 130. For example, in a case of downlink transmission, the user equipment 110 may estimate a downlink channel. In particular, in a case of OFDM transmission, the user equipment 110 may estimate a channel of each

subcarrier. Conversely, in a case of uplink transmission, the base station 120 may estimate an uplink channel.

~~[45]~~**[0047]** For the channel estimation, a predetermined signal or symbol may be inserted into a frequency-domain grid at regular or irregular intervals. In this example, the predetermined signal or symbol may be referred to as a reference signal or a reference symbol, a pilot symbol, and the like. In the specifications, the predetermined signal or symbol is referred to as a reference signal, but this may not be limited thereto. The reference signal 130 may not be used for only the estimation of the frequency-domain channel, but may be used for estimation of a location required for wireless communication between a user equipment and a base station, transmission and reception of control information, transmission and reception of scheduling information, transmission and reception of feedback information, and the like.

~~[46]~~**[0048]** There may be various types of reference signals for downlink or uplink transmission, and new reference signals for various purposes have been defined and discussed. For example, reference signals for the uplink transmission may include a DM-RS (Demodulation RS), an SRS (Sounding RS), and the like. Reference signals for the downlink transmission may include a DM-RS (Demodulation RS), CRS (Cell-specific RS), an MBSFN RS, a UE-specific RS, and the like. Also, a CSI-RS is used as a reference signal that a base station transmits to obtain channel status information (CSI) of a center cell or adjacent cells from the user equipment 110 in a case of downlink transmission. The CSI-RS may be used for

reporting a CQI (Channel Quality Indicator)/PMI (Precoder Matrix Indicator)/RI (Rank Indicator), and the like. The CSI-RS may be cell-specific so as to be distinguished for each cell included in a base station that transmits the CSI-RS, and may need to be sufficiently scattered in a frequency and a time for a low overhead.

~~[47]~~**[0049]** Referring again to FIG. 2, the user equipment 110 stores a first codebook 112 that expresses N first precoding matrices used for a first precoder and first indices indexing the first precoding matrices and a second codebook 114 that expresses M second precoding matrices used for a second precoder and second indices indexing the second precoding matrices. The first codebook 112 and the second codebook 114 may be identical to the first codebook 122 and the second codebook 124 stored in the base station 120, respectively.

~~[48]~~**[0050]** The user equipment 110 stores a restriction book 116, which will be described with reference to Table 4, including ranks and a plurality of indices (hereinafter referred to as a restriction index) corresponding to each pair of a first index and a second index included in each rank. The restriction book 116 stored in each user equipment 110 may be identical to the restriction book 126 stored in the base station 120.

~~[49]~~**[0051]** The user equipment 110 may receive codebook restricting information 128 from the base station 120. The codebook restricting information 128 includes at least one of first information that restricts a precoding matrix from being used as a first precoding matrix and second information that restricts a precoding matrix from being used as a second precoding

matrix in first and second codebooks for each layer.

~~[50]~~**[0052]** The user equipment 110 determines, based on the first information included in the codebook restricting information 128, a first precoding matrix excluding precoding matrices that are restricted from being used as a first precoding matrix, and reports/feeds back 1st channel status information 132 associated with the determined precoding matrix to the base station 120. Also, each user equipment 110 determines, based on the second information included in the codebook restricting information 128, a second precoding matrix excluding precoding matrices that are restricted from being used as a second precoding matrix, and reports/feeds back 2nd channel status information 134 associated with the determined second precoding matrix to the base station 120.

~~[51]~~**[0053]** The base station 120 determines precoding matrices of the first precoder and the second precoder from the first codebook 122 and the second codebook 124 based on the channel status information 132 and 134 reported from each user equipment 110, and performs precoding of data symbols using the precoding matrices.

~~[52]~~**[0054]** Referring again to FIG. 3, the base station 120 transmits a precoded signal 136 to the user equipment 110 as illustrated in FIG. 3. Conversely, the user equipment 110 receives the signal 136 and decodes the signal into original data.

~~[53]~~**[0055]** The process has been described in which a base station and a user equipment exchange codebook restricting information and channel status information in the

wireless communication system when a multistage precoder is used in a case of codebook restriction. Hereinafter, a MIMO wireless communication system that transmits and receives codebook restricting information and the channel station information will be described.

~~[54]~~**[0056]** FIG. 4 is a block diagram illustrating a base station and a user equipment in a MIMO wireless communication system according to an embodiment of the present invention. FIG. 5 illustrates a channel between a base station and a user equipment that uses a polarized antenna array of FIG. 4.

~~[55]~~**[0057]** Referring to FIG. 4, a MIMO wireless communication system may include a user equipment 410 and a base station 420.

~~[56]~~**[0058]** The user equipment 410 includes an antenna array 411 to receive a signal through a downlink channel, a post-decoder 412 to process a received signal and to decode the received signal into original data using a precoding matrix, and a channel information feedback device 414.

~~[57]~~**[0059]** The antenna array 411 may use a plurality of antennas. In this example, the antenna array 411 may form a polarized antenna array. The array may be embodied as a dual polarized antenna array in which two antennas having different polarities intersect each other so as to arrange a larger number of antennas in a limited space.

~~[58]~~**[0060]** Referring to FIG. 5, when "+" indicates a direction polarizing to the right from the vertical direction and "-" indicates a direction polarizing to the left from the

vertical direction, the user equipment 410 includes a polarized antenna array 411 including two pairs of antennas in which antennas 411aa and 411ab polarized at 45 degrees from the vertical direction and antennas 411ba and 411bb polarized at -45 degrees from the vertical direction intersect to each other, respectively. In this example, the antennas 411aa and 411ab polarized at +45 degrees may be referred to as a first domain 411a or a first subset of a transmitting side, and the antennas 411ba and 411bb polarized at -45 degrees may be referred to as a second domain 411b or a second subset of the transmitting side.

~~[59]~~**[0061]** Referring again to FIG. 4, the post-decoder 412 may correspond to a first precoder 422 and a second precoder 424 of the base station 420. The post-decoder may transfer a received reference signal to the channel information feedback device 414.

~~[60]~~**[0062]** The channel information feedback device 414 may receive a reference signal and may estimate a channel using the reference signal. The channel information feedback device 414 may generate channel information including 1st channel status information and 2nd channel station information. The channel information feedback device 414 may feed back the channel information to the base station 420.

~~[61]~~**[0063]** The base station 420 may include a layer mapper 421 to map a codeword to a layer, a precoder 425 to perform precoding of data symbols obtained through the layer mapping using a precoding matrix, and an antenna array 428 to transmit a precoded signal on air. The precoder 425 may include the first precoder 422 and the second precoder 424 to

perform precoding of data symbols. In this example, the first precoder 422 and the second precoder 424 may perform precoding of data symbols using a corresponding first precoding matrix and a corresponding second precoding matrix, respectively.

~~[62]~~**[0064]** The antenna array 428 of the base station 420 may use a plurality of antennas. In this example, the antenna array 428 may form a polarized antenna array. An array may be embodied as a dual polarized antenna array in which two antennas having different polarities intersect each other so as to arrange a larger number of antennas in a limited space in a wireless communication system. In this example, although it is described that the antenna arrays 411 and 428 use a dual polarized antenna array, this may not be limited thereto.

~~[63]~~**[0065]** Referring to FIG. 5, the base station 420 includes a polarized antenna array 428 including four pairs of antennas in which antennas 428aa through 428ad polarized at 45 degrees from the vertical direction and antennas 428ba through 428bd polarized at -45 degrees intersect each other, respectively. In this example, the antennas 428aa through 428ad polarized at +45 degrees are referred to as a first domain 428a or a first subset of a receiving side, and the antennas 428ba through 428bd polarized at -45 degrees are referred to as a second domain 428b or a second subset of a receiving side.

~~[64]~~**[0066]** When a phase mismatch does not exist between polarized antennas of the user equipment 410 and the base station 420, an overall channel H may be expressed as shown in Equation 1.

~~[65]~~**[0067]** ~~[Equation1]~~Equation 1

~~[66]~~

$$H = \begin{bmatrix} H_h & 0 \\ 0 & H_v \end{bmatrix}$$

~~[67]~~**[0068]** In this example, H_h denotes a channel between the first subset or the first domain 411a of the user equipment 410 and the first subset or the first domain 428a of the base station 420, and H_v denotes a channel between the second subset or the second domain 411b and the second subset or the second domain 428b of the base station 420.

~~[68]~~**[0069]** As shown in Equation 1, when antennas polarized to different directions intersect each other and have no phase mismatch, the antennas may not affect each other. Therefore, only H_h and H_v may be estimated and thus, a channel may be recognized. When a distance d between adjacent polarized antennas is shorter than a signal wavelength λ, a correlation between antennas may be high. In this example, H_h and H_v may be determined based on a distance d between antennas and an incident angle θ of signal propagation that arrives at the user equipment 410.

~~[69]~~**[0070]** When a phase mismatch exists between polarized antennas of the user equipment 410 and the base station 420, for example, when pairs of antennas of the user equipment 410 are tilted to the left by ε, signals transmitted from each polarized domain of

the base station 420 may be received by two polarized domains of the user equipment 410 and thus, inter-domain interference may occur due to a phase mismatch between the domains. Therefore, a channel may be affected by a degree of a phase error or a phase mismatch between polarized antennas of the user equipment 410 and the base station 420, that is, by ε, and thus, the overall channel H may be expressed by Equation 2.

~~[70]~~**[0071]** ~~[Equation 2]~~Equation 2

~~[71]~~

$$H = \begin{bmatrix} H_h \cos\varepsilon & -H_v \sin\varepsilon \\ H_h \sin\varepsilon & H_v \cos\varepsilon \end{bmatrix}$$

~~[72]~~**[0072]** Referring again to FIG. 4, the second precoder 424 may correct a phase mismatch to remove an effect from a phase error or a phase mismatch between polarized domains formed by the antenna array 428 including antennas intersecting in a horizontal direction and a vertical direction, and the first precoder may perform intra-domain precoding.

~~[73]~~**[0073]** When a dual polarized domain is configured based on a scheme of arranging two antennas at the same location, each polarized domain may have an identical spatial channel characteristic. That is, each domain may be precoded based on an identical precoding matrix ($H_h = H_v = R_0$), and a signal transmitted through each polarized domain may have a different phase and size when arriving at the user equipment 410. In this example, a first

precoding matrix and a second precoding matrix used in the first precoder 422 and the second precoder 424 may be expressed by Equation 3.

~~[74]~~**[0074]** ~~[Equation 3]~~Equation 4

~~[75]~~

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

~~[76]~~**[0075]** In Equation 3, R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

~~[77]~~**[0076]** A size of a signal received in each domain may be determined by a precoding gain of R_0 of a first precoding matrix W_1, a second precoding matrix W_2 corrects a phase mismatch between signals received in respective domains. When an operation proceeds in this manner, a first index PMI_1 for setting the first precoding matrix W_1 and a second index PMI_2 for setting the second precoding matrix W_2 may be independently selected.

~~[78]~~**[0077]** As shown in Equation 3, the precoder 425 is a precoder configured of a first precoding matrix that performs precoding using R_0 determined by a precoding gain in each of the two domains (a polarized domain or a subset of antennas) and a second precoding matrix

that performs phase mismatch correction (co-phasing) between domains. Therefore, each of the two independent domains may be precoded by R_0 determined by a precoding gain, and one of the domains may be phase-corrected by $\wedge$ and may be transmitted.

~~[79]~~**[0078]** In the precoder 425, the second precoding matrix corresponds to a precoding matrix that corrects signal attenuation caused by a phase error between polarized domains in polarized antennas. Also, the second precoding matrix may correspond to a precoding matrix to correct signal attenuation caused by a phase error between polarized domains, or may correspond to a precoding matrix to correct a phase mismatch that naturally occurs between polarized antennas. The base station 420 stores a first codebook that expresses N (N is a natural number greater than or equal to 1) first precoding matrices used for the first precoder 422 and first indices indexing the first precoding matrices, and a second codebook that expresses M (M is a natural number greater than or equal to 1) second precoding matrices and second indices indexing the second precoding matrices.

~~[80]~~**[0079]** Table 2 and Table 3 correspond to examples of the first codebook and the second codebook that use 16 precoding matrices and 4 precoding matrices for each rank, respectively, when the antenna array 428, including 8 dual polarized antennas 428a and 428b, simultaneously transmits a total of 8 layers.

~~[81]~~**[0080]** ~~[Table 2]~~Table 2

~~[82]~~

RI \ PMI_1	0	1	2	.....	15
1	b0	b1	b2	.....	b15
2	b16	b17	b18	.....	b31
.....	.....	.....	.....	.....	.....
8	b112	b113	b114	.....	b127

~~[83]~~**[0081]** ~~[Table 3]~~Table 3

~~[84]~~

RI \ PMI_2	0	1	2	3
1	c0	c1	c2	c3
2	c4	c5	c6	c7
.....	.....	.....	.....	.....
8	c28	c29	c30	c31

~~[85]~~**[0082]** The base station 420 stores a restriction book including ranks and an index (hereinafter referred to as a restriction index) corresponding to each pair of a first index and a second index for each rank. Table 4 corresponds to a restriction book that uses 16 precoding matrices and 4 precoding matrices for each rank when the antenna array 428, including 8 dual polarized antennas 428a and 428b, simultaneously transmits a total of 8 layers.

~~[86]~~**[0083]** ~~[Table 4]~~Table 4

~~[87]~~

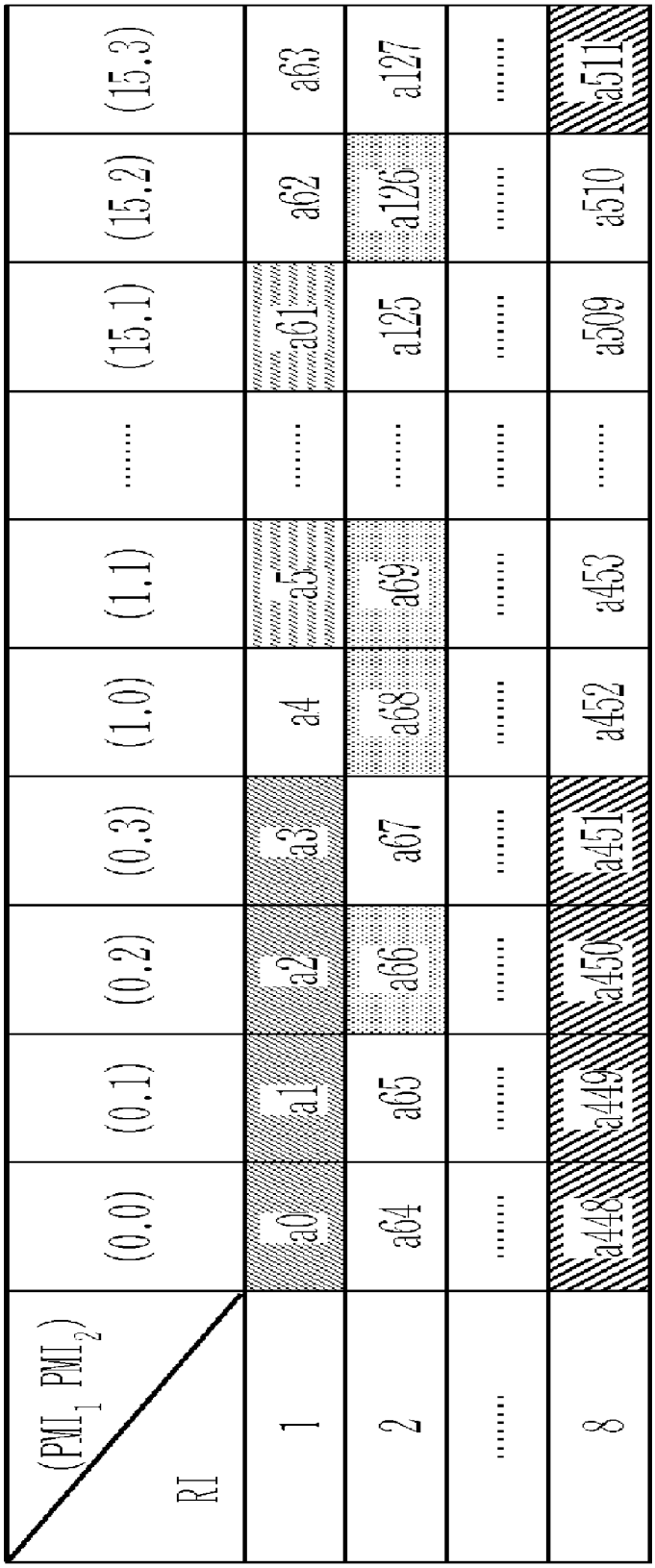
RI \ (PMI_1 PMI_2)	(0.0)	(0.1)	(0.2)	(0.3)	(1.0)	(1.1)	.....	(15.1)	(15.2)	(15.3)
1	a0	a 1	a 2	a 3	a4	a5	.....	a61	a62	a63
2	a61	a65	a66	a67	a68	a69	.....	a125	a126	a127
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	a448	a449	a450	a451	a452	a453	.....	a509	a510	a511

~~[88]~~**[0084]** In a case of codebook restriction, when codebook restricting information is transmitted based on a bitmap format that designates whether each precoding matrix is to be used using one bit, a total of 16x4x8=512 bits may be required for the ranks and pairs of a first index and a second index for respective ranks.

~~[89]~~**[0085]** However, as described in the foregoing, a first index PMI_1 for setting a first precoding matrix W_1 and a second index PMI_2 for setting a second precoding matrix W_2 may be independently selected and thus, a codebook may be restricted independently with respect to each precoding matrix, for each rank and for each of the first precoder and the second precoder. Table 5 expresses precoders that are restricted in a restriction book when codebook restriction is determined with respect to the first index=0 (PMI_1=0) and the second index=1 (PMI_2=1) in a rank 1.

~~[90]~~**[0086]** ~~[Table 5]~~Table 6

~~[91]~~



RI \ (PMI_1, PMI_2)	(0,0)	(0,1)	(0,2)	(0,3)	(1,0)	(1,1)	.....	(15,1)	(15,2)	(15,3)
1	a0	a1	a2	a3	a4	a5	.....	a61	a62	a63
2	a64	a65	a66	a67	a68	a69	.....	a125	a126	a127
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	a448	a449	a450	a451	a452	a453	.....	a509	a510	a511

~~[92]~~**[0087]** Although not illustrated in Table 5, a codebook restriction may be independently performed on a first precoding matrix and a second precoding matrix with respect to 8 ranks, in the same manner as the codebook restriction performed on the rank 1.

~~[93]~~**[0088]** The base station 420 determines a precoding matrix to be used/not used for each cell or for each user equipment, and transmits codebook restricting information associated with the precoding matrix to be not used to the user equipment 410. In this example, the codebook restricting information may include first information that restricts a precoding matrix from being used as a first precoding and second information that restricts a precoding matrix from being used as a second precoding matrix in the first and second codebooks for each layer.

~~[94]~~**[0089]** As shown in Table 5, when codebook restriction on a first index=0 (PMI_1=0) and a second index=1 (PMI_2=1) is determined with respect to the rank 1, codebook restricting information may include $[0111111111111111]$ corresponding to first information and $[1011]$ corresponding to second information in a bitmap format. As described in the foregoing, a corresponding order of an available precoding matrix is expressed to be 1, and a corresponding order of a precoding matrix not to be used is expressed to be 0. Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=0 (PMI_1=0), for example, (PMI_1, PMI_2) = (0,1), (0,1), (0, 2), (0,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the

second index=1 (PMI_2=1), for example, (PMI_1, PMI_2) = (0,1), (1,1), …, (14,1), (15,1) in table 5.

~~[95]~~**[0090]** When a codebook restriction on a first index=1 (PMI_1=1) and a second index=2 (PMI_2=2) is determined with respect to a rank 2, codebook restricting information may include [1011111111111111] corresponding to first information and [1101] corresponding to second information. Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=1 (PMI_1=1), for example, (PMI_1, PMI_2) = (1,1), (1,1), (1,2), (1,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=2 (PMI_2=2), for example, (PMI_1, PMI_2) = (0,2), (1,2), …, (14,2), (15,2) in table 5.

~~[96]~~**[0091]** When a codebook restriction on a first index=0 (PMI_1=0) and a second index=3 (PMI_2=3) is determined with respect to a rank 8, codebook restricting information may include [0111111111111111] corresponding to first information and [1110] corresponding to second information. Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=0 (PMI_1=0), for example, (PMI_1, PMI_2) = (0,1), (0,1), (0, 2), (0,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=3 (PMI_2=3), for example, (PMI_1, PMI_2) = (0,3), (1,3), …, (14,3), (15,3) in table 5.

~~[97]~~**[0092]** In other words, the codebook restricting information includes the first information and the second information. Accordingly, when a first precoding matrix is

restricted from being used as a first precoding matrix based on the first information, the use of second precoding matrices that make pairs with the restricted first precoding matrix may be restricted. When a second precoding matrix is restricted from being used as a second precoding matrix based on the second information, the use of first precoding matrices that make pairs with the restricted second precoding matrix may be restricted.

~~[98]~~**[0093]** In the same manner, codebook restricting information with respect to each of a rank 3 through a rank 7 may include first information and second information in a bitmap format. In this example, although the codebook restricting information including the first information and the second information is provided in a bitmap format, this is merely an example and may not be limited thereto.

~~[99]~~**[0094]** In the same manner described in the foregoing, when the rank 1 through rank 8 transmit codebook restricting information based on the same bitmap format, a total number of bits of the codebook restricting information that independently restricts a first precoding matrix and a second precoding matrix with respect to a total of 8 ranks may be (16 + 4) x 8 = 160.

~~[100]~~**[0095]** The base station 420 may transmit, to the user equipment 410, codebook restricting information that expresses codebook restriction based on a bitmap format using 20 bits for each rank, that is, a total of 160 bits for the rank 1 through the rank 8. The codebook restricting information may be transmitted as downlink control information, for

example, an RRC signal, from the base station 420 to the user equipment 410 through a Physical Downlink Shared Channel (PDSCH). In this example, the codebook restricting information may be transmitted from the base station 420 to the user equipment 410 through a Physical Downlink Control Channel (PDCCH) in addition to the PDSCH. In this example, the codebook restricting information may sequentially include first information and second information for each rank. For example, the codebook restricting information may include first information and second information associated with the rank 1, first information and second information associated with the rank 2,…, and first information and second information associated with the rank 8, sequentially.

~~[101]~~**[0096]** The codebook restricting information may sequentially include first information for each rank, and then may sequentially include second information for each rank. For example, the codebook restricting information may sequentially include first information associated with the rank 1 through the rank 8, and then may sequentially include second information associated with the rank 1 through the rank 8. The first information and the second information included in the codebook restricting information may be independently transmitted for each rank from the base station 420 to the user equipment 410. When a codebook is not restricted for a predetermined rank, codebook restricting information associated with the predetermined codebook may not be included.

~~[102]~~**[0097]** Accordingly, when a pair of a first index and a second index is

restricted, codebook restricting information of a total of 512 bits is required. However, when restriction on a first index and a second index is independently determined and transmitted, an amount of feedback overhead of the codebook restriction may be significantly reduced.

~~[103]~~**[0098]** When the first precoder 422 performs intra-domain precoding using a first precoding matrix, for example, in a case where a codebook is restricted so that precoding matrices expressed to be a first index=7 (PMI_1=7) are not to be used since an intra-domain precoding gain is small, any precoding matrix that is expressed to be PMI_1=7 when the second precoder 424 performs phase mismatch correction using a second precoding matrix may not obtain an excellent precoding gain.

~~[104]~~**[0099]** That is, determining restriction on a first precoding matrix that performs intra-domain precoding may take precedence over determining restriction on a second precoding matrix that performs phase mismatch correction. Therefore, when a codebook restriction is performed, only the first precoding matrix may be restricted. In this example, the codebook restricting information includes only first information that restricts the first precoding matrix and thus, a total of 16 x 8= 128 bits may be required.

~~[105]~~**[0100]** When inter-domain phase mismatch interference takes precedence in a condition of the same inter-domain interference, only the second precoding matrix may be restricted. In this example, the codebook restricting information includes only second information that restricts the second precoding matrix and thus, a total of 4 x 8 = 32 bits may be

required.

~~[106]~~**[0101]** As described in the foregoing, a scheme that restricts both the first precoding matrix and the second precoding matrix, independently, a scheme that restricts only the first precoding matrix, and a scheme that restricts only the second precoding matrix may be selectively used. In this example, the base station 420 may transmit, to the user equipment 410, a restriction mode indicator of a total of 2 bits that indicates a restriction mode.

~~[107]~~**[0102]** The channel information feedback device 414 of the user equipment 410 determines a first precoding matrix excluding precoding matrices that are restricted from being used as a first precoding matrix based on first information included in codebook restricting information, and reports/feeds back, to the base station 420, 1st channel status information associated with the first precoding matrix. In the example provided in the foregoing, when [0111111111111111] corresponding to first information of a bitmap format that restricts a codebook with respect to a first index = 0 (PMI_1=0) in a rank 1 is received, the channel information feedback device 414 determines a first precoding matrix from among precoding matrices corresponding to indices excluding the first index=0 (PMI_1=0), that is, from among precoding matrices excluding precoding matrices corresponding the first index=0, and reports/feeds back 1st channel status information associated with the first precoding matrix to the base station. Also, each user equipment 410 determines a second precoding matrix excluding matrices that are restricted from being used as a second precoding matrix based on second

information included in codebook restricting information, and reports/feeds back, to the base station 420, 2nd channel status information associated with the second precoding matrix. In the example provided in the foregoing, when [1011] corresponding to second information of a bitmap format that restricts a codebook with respect to a second index =1 (PMI_2=1) in a rank 2 is received, the channel information feedback device 414 determines a second precoding matrix from among precoding matrices corresponding to indices excluding the second index=1 (PMI_2=1), that is, from among precoding matrices excluding precoding matrices corresponding to the second index=1, and reports/feeds back 2nd channel status information associated with the second precoding matrix to the base station.

~~[108]~~**[0103]** When [1011111111111111] corresponding to first information and [1101] corresponding to second information of a bitmap format that restrict a codebook with respect to a first index=1 (PMI_1=1) and a second index=2 (PMI_2=2) in the rank 2 are received, the channel information feedback device 414 determines a first precoding matrix and a second precoding matrix excluding precoding matrices corresponding to the first index=1 (PMI_1=1) and the second index=2 (PMI_2=2) with respect to the rank 2 as shown in Table 5, and reports/feeds back, to the base station, the associated 1st channel status information and 2nd channel status information. In the same manner, the channel information feedback device 414 may determine a first precoding matrix and a second precoding matrix excluding precoding matrices designated by first information and second information, with respect to the rank 3

through the rank 8.

~~[109]~~**[0104]** As described in the foregoing, a scheme that restricts both the first precoding matrix and the second precoding matrix, independently, a scheme that restricts only the first precoding matrix, and a scheme that restricts only the second precoding matrix may be selectively used. When the base station 420 transmits, to the user equipment 410, a restriction mode indicator of a total of 2 bits that indicates a restriction mode, the channel information feedback device 414 of the user equipment 410 may determine a first precoding matrix and a second precoding matrix based on the restriction mode, and generates and reports 1st channel status information and 2nd channel status information.

~~[110]~~**[0105]** A feedback period or interval of the 1st channel status information and the 2nd channel status information may be different from each other. For example, the 1st channel status information may be fed back to the base station 420 based on a short term, and the 2nd channel status information may be fed back to the base station 420 based on a long term. In other words, a long period/long term and a short period/short term are relative terms, and the long period/long term indicates a period that is longer than the short period/short term.

~~[111]~~**[0106]** The first precoder 422 and the second precoder 424 of the base station 420 determine first and second precoding matrices based on/using channel status information reported from each user equipment 410, and perform precoding of data symbols using the precoding matrices.

~~[112]~~**[0107]** The MIMO wireless communication system that transmits and receives codebook restricting information and channel status information according to another embodiment of the present invention has been described. Hereinafter, a communication method of a transmitting device according to another embodiment of the present invention will be described.

~~[113]~~**[0108]** FIG. 6 is a flowchart illustrating a communication method of a transmitting device according to another embodiment of the present invention.

~~[114]~~**[0109]** Referring to FIG. 6, a communication method 600 of a transmitting device according to another embodiment of the present invention includes a layer mapping step S610 to map a codeword to a layer, a precoding step S620 to perform precoding of symbols, and a transmitting step S630 to propagate a precoded symbol into air through two or more antennas. The layer mapping step S610, the precoding step S620, and the transmitting step S630 are identical as described in the foregoing and thus, detailed descriptions thereof will be omitted.

~~[115]~~**[0110]** A communication method 600 of a base station according to another embodiment of the present invention independently performs codebook restriction on a first precoding matrix of Table 3 and a second precoding matrix of Table 4 with respect to each rank by referring to Table 5, and transmits, to the user equipment 410, codebook restricting information that expresses codebook restriction in a bitmap format using 20 bits for each rank, that is, a total of 160 bits from a rank 1 through a rank 8. The codebook restricting information

may be transmitted as downlink control information, for example, an RRC signal, from the base station 420 to the user equipment 410 through a Physical Downlink Shared Channel (PDSCH). In this example, the codebook restricting information may be transmitted from the base station 420 to the user equipment 410 through another channel such as a Physical Downlink Control Channel (PDCCH) in addition to the PDSCH.

~~[116]~~**[0111]** In the layer mapping step S610, the codebook restricting information may be mapped to a layer as a downlink control signal.

~~[117]~~**[0112]** The base station 420 determines a precoding matrix to be used/not to be used for each cell or each user equipment, and transmits codebook restricting information associated with the precoding matrix to the user equipment 410. In this example, the codebook restricting information includes first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix in first and second codebooks for each layer.

~~[118]~~**[0113]** As shown in Table 5, when codebook restriction is determined with respect to a first index=0 (PMI_1=0) and a second index=1 (PMI_2=1) in a rank 1, codebook restricting information may include [0111111111111111] corresponding to first information and [1011] corresponding to second information in a bitmap format.

~~[119]~~**[0114]** The precoding step S620 may perform precoding of a data symbol obtained through layer mapping, using a first precoding matrix and a second precoding matrix

selected from a corresponding codebook. In this example, the precoding step S620 may perform precoding of data symbols using a first precoding matrix and a second precoding matrix corresponding to a first index and a second index received from a receiving device such as a user equipment. In this example, the first index and the second index received from the receiving device may correspond to indices associated with precoding matrices selected from precoding matrices excluding precoding matrices that are restricted based on the codebook restricting information in the first codebook of Table 3 and the second codebook of Table 4.

~~[120]~~**[0115]** As described in the foregoing, the transmitting device such as a base station may include at least one antenna pair in which at least one antenna polarized in one direction and at least one antenna polarized in another direction intersect each other.

~~[121]~~**[0116]** In this example, as described with reference to Equation 3, a first precoding matrix performs precoding between one antenna and another antenna that intersect each other, and a second precoding matrix performs phase mismatch correction between one antenna and another antenna.

~~[122]~~**[0117]** The communication method of the transmitting device has been described. Hereinafter, a communication method of a receiving device will be described.

~~[123]~~**[0118]** FIG. 7 is a flowchart illustrating a communication method of a receiving device according to another embodiment of the present invention.

~~[124]~~**[0119]** A communication method 700 of a receiving device may include a

codebook restricting information receiving step S710 to receive codebook restricting information from a transmitting device, and a channel information transmitting step S720 to transmit 1st channel status information and 2nd channel status information to the transmitting device.

~~[125]~~**[0120]** The codebook restricting information receiving step S710 may receive first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix for each layer. In this example, the codebook restricting information includes first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix in a first codebook and a second codebook for each layer. The channel information transmitting step S720 transmits, to the transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix being selected, based on codebook restricting information, from precoding matrices that are not restricted from being used as a first precoding matrix or a second precoding matrix in a codebook.

~~[126]~~**[0121]** Step S710 and step S720 will be described in detail in the following. When the receiving device receives $[0111111111111111]$ corresponding to first information and $[1011]$ corresponding to second information in a bitmap format that restrict a codebook with respect to a first index=0 (PMI_1=0) in a rank 1 in step S710, the receiving device

determines a first precoding matrix from among precoding matrices corresponding to indices excluding the first index=0 (PMI_1=0), that is, from among precoding matrices excluding precoding matrices corresponding to the first index=0, as shown in Table 5, and reports/feeds back associated 1st channel status information to a base station, and determines a second precoding matrix from among precoding matrices corresponding to indices excluding the second index=1 (PMI_2=1), that is, from among precoding matrices excluding precoding matrices corresponding to the second index = 1, and reports/feeds back associated 2nd channel status information to the base station in step S720.

~~[127]~~**[0122]** Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=0 (PMI_1=0), for example, (PMI_1, PMI_2) = (0,1), (0,1), (0, 2), (0,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=1 (PMI_2=1), for example, (PMI_1, PMI_2) = (0,1), (1,1), …, (14,1), (15,1) in table 5.

~~[128]~~**[0123]** When the receiving device receives [1011111111111111] corresponding to first information and [1101] corresponding to second information of a bitmap format that restrict a codebook with respect to a first index = 1 (PMI_1=1) and a second index = 2 (PMI_2=2) in a rank 2 in step S710, the receiving device determines a first precoding matrix and a second precoding matrix excluding precoding matrices corresponding to the first index = 1 (PMI_1=1) and the second index = 2 (PMI_2=2) for the rank 2 as shown in Table 5, and

reports/feeds back associated 1st channel status information and associated 2nd channel status information to the base station in step S720.

~~[129]~~**[0124]** Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=1 (PMI_1=1), for example, (PMI_1, PMI_2) = (1,1), (1,1), (1, 2), (1,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=2 (PMI_2=2), for example, (PMI_1, PMI_2) = (0,2), (1,2), …, (14,2), (15,2) in table 5.

~~[130]~~**[0125]** In other words, the codebook restricting information includes the first information and the second information. Accordingly, when a first precoding matrix is restricted from being used as a first precoding matrix based on the first information, the use of second precoding matrices that make pairs with the restricted first precoding matrix may be restricted. When a second precoding matrix is restricted from being used as a second precoding matrix based on the second information, the use of first precoding matrices that make pairs with the restricted second precoding matrix may be restricted.

~~[131]~~**[0126]** In the same manner, the receiving device may determine a first precoding matrix and a second precoding matrix for each of a rank 3 through a rank 8, excluding precoding matrices designated by first information and second information.

~~[132]~~**[0127]** The process in which a base station and a user equipment exchange codebook restricting information and channel status information in a wireless communication

system when a codebook is restricted in a case where a multistage precoder is used, a MIMO wireless communication system that transmits and receives codebook restricting information and channel status information, and the transceiving method or communication method of the transmitting device and the receiving device in the wireless communication system have been described.

~~[133]~~**[0128]** According to the embodiments of the present invention, information to restrict precoding matrices is determined for each multistage precoder, and codebook restricting information including the determined information is transmitted and thus, an amount of transmission overhead of the codebook restricting information may be reduced. According to the embodiments of the present invention, the wireless communication system uses the codebook restriction scheme and thus, inter-cell interference may be controlled.

~~[134]~~**[0129]** According to a definition of a precoding matrix as described with reference to Equation 3, a precoding gain in each domain or a subset of an antenna is determined by a first precoding matrix. That is, an overall precoding gain is determined by a gain associated with the first precoding matrix and a coding gain of a second precoder matrix that performs phase mismatch correction (co-phasing) between domains or subsets. In this example, the second precoding matrix performs phase mismatch correction (co-phasing) between domains or subsets and thus, a maximum precoding gain that each user equipment is able to obtain may be determined by the first precoding matrix. In other words, power or receivable maximum

power of a signal that each user equipment receives is determined by a first precoder or a first precoding matrix, and a second precoder or a second precoding matrix performs only phase correction of a signal received by each domain or subset of an antenna. Interference by multiple-access may be significantly affected by a first precoder or a first precoding matrix.

~~[135]~~**[0130]** FIGS. 8 through 10 are conceptual diagrams illustrating a process of controlling inter-cell interference using a codebook restriction scheme in a wireless communication system according to embodiments of the present invention.

~~[136]~~**[0131]** Referring to FIG. 8, inter-cell interference may occur among cell edge user equipments 810a through 810d during beamforming. For example, user equipments 810a and 810b exist in a coverage of a first base station and a second base station as shown in FIG. 8 and thus, when a signal is transmitted that is precoded based on a first precoding matrix associated with a PMI_1=4 or PMI_1=6 of the first base station of a first cell 820a, transmission of a signal that is precoded based on a first precoding matrix associated with a PMI_1=13 of the second base station or a second cell 820b may cause interference.

~~[137]~~**[0132]** In other words, the user equipments 810a and 810b receive both the transmitted signal that is precoded based on the first precoding matrix associated with the PMI_1=4 or PMI_1=6 of the first base station or the first cell 820a and the transmitted signal that is precoded based on the first precoding matrix associated with a PMI_1=13 of the second base station or the second cell 820b and thus, interference may occur.

~~[138]~~**[0133]** Also, user equipments 810c and 810d exist in a coverage of the first base station and the second base station as shown in FIG. 8 and thus, when a signal is transmitted that is precoded based on a first precoding matrix associated with a PMI_1=8 of the first base station 820a, transmission of a signal that is precoded based on a first precoding matrix associated with a PMI_1=2 or a PMI_1=11 of the second base station 820b may cause interference.

~~[139]~~**[0134]** The descriptions may be specifically provided using the user equipment 810b as an example as follows. The user equipment 810b receives a signal from both the first base station 820a and the second base station 820b as shown in FIG. 8. The first base station 820a transmits a signal using the first precoding matrix corresponding to the PMI_1=6 to transmit a signal to the user equipment 810b, and the second base station 820b uses the first precoder matrix corresponding to the PMI_1=13 to transmit a signal to the user equipment 810b. Accordingly, as illustrated in FIG. 8, when the second base station 820b transmits a signal to the user equipment 810b using the PMI_1=13, another user equipment 810a may receive multiple-access interference by the signal transmitted to the user equipment 810b.

~~[140]~~**[0135]** When the second base station 820b restricts a codebook so that the first precoder matrix corresponding to the PMI_1=13 is not to be used, the user equipment 810b receives a signal from only the first base station 820a and thus, inter-cell interference due to multiple-interference may be prevented in advance.

~~[141]~~**[0136]** Other user equipments 810c and 810d may receive multiple-access

interference due to inter-cell interference, like the user equipments 810a and 810b.

~~[142]~~**[0137]** When the first base station 820a restricts a codebook so that the first precoder matrix corresponding to the PMI_1=8 is not to be used, user equipments 810c and 810d receive a signal from only the second base station 820b and thus, inter-cell interference due to multiple-interference may be prevented in advance.

~~[143]~~**[0138]** FIG. 9 conceptually illustrates a case in which a first precoding matrix or an associated index that is expected to cause inter-cell interference is restricted by performing a codebook restriction based on the above-mentioned scheme, and a downlink MIMO is performed based on the restriction.

~~[144]~~**[0139]** Referring to FIG. 9, when each base station 820a and 820b performs a PMI_1=13 based codebook restriction that restricts the use of a first precoding matrix corresponding to a PMI_1=13 or a PMI_1=8, occurrence of inter-cell interference may be avoided or reduced as illustrated in FIG. 9. Therefore, when a codebook restriction is applied to only a PMI_1 and is not applied to a PMI_2, inter-cell interference may be removed.

~~[145]~~**[0140]** Referring to FIG. 10, the user equipment 810b receives signals precoded based on a first precoding matrix associated with a PMI_1=6 of a first base station and a first precoding matrix associated with a PMI_1=13 of a second base station and thus, interference may occur. The user equipment 810c receives signals precoded based on a first precoding matrix associated with a PMI_1=8 of the first base station and a first precoding matrix associated

with a PMI_1=2 of the second base station and thus, interference may occur. In this example, the first base station may allow the use of the PMI_1=6 and may restrict the use of the PMI_1=2, and conversely, the second base station may allow the use of the PMI_1=2 and may restrict the use of the PMI_1=6 and thus, interference between user equipments may be removed.

~~[146]~~**[0141]** As another example, to remove interference between user equipments, the first base station may allow the use of the PMI_1=8 and may restrict the use of the PMI_1=13, and conversely, the second base station may allow the use of the PMI_1=13 and may restrict the use of the PMI_1=8.

~~[147]~~**[0142]** As another example, to remove interference between user equipments, the first base station may allow the use of the PMI_1=6 and the PMI_1=8 and the second base station may restrict the use of the PMI_1=6 and the PMI_1=8. Conversely, the first base station may restrict the use of the PMI_1=6 and the PMI_1=8 and the second base station may allow the use of the PMI_1=6 and the PMI_1=8.

~~[148]~~**[0143]** As described in the foregoing, when each base station 820a and 820b performs the PMI_1 based codebook restriction, occurrence of inter-cell interference may be avoided or reduced.

~~[149]~~**[0144]** Also, when codebook restriction is applied with respect to only the PMI_2, there is an advantage in that a codebook is restricted by a small number of bits. Also, no restriction is applied to the PMI_1 that directly controls a precoding gain and thus, more precise

precoding is available and a size of a codebook may be reduced.

~~[150]~~**[0145]** Although the embodiments of the present invention have been described in detail, the present invention may not be limited thereto.

~~[151]~~**[0146]** The embodiments of the present invention may be applied to an up/downlink MIMO system, and may be applied to all up/downlink MIMO systems such as a Coordinated multi-point transmission/reception system (CoMP), a heterogeneous network, and the like, in addition to a single cell environment.

~~[152]~~ Although a preferred embodiment of the present invention has been described for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims. Therefore, the embodiments disclosed in the present invention are intended to illustrate the scope of the technical idea of the present invention, and the scope of the present invention is not limited by the embodiment. The scope of the present invention shall be construed on the basis of the accompanying claims in such a manner that all of the technical ideas included within the scope equivalent to the claims belong to the present invention.

~~[153]~~ ~~**CROSS-REFERENCE TO RELATED APPLICATION**~~

~~[154]~~**[0147]** ~~This application claims priority from and the benefit under 35 U.S.C. §119(a) of Korean Patent Application No. 10-2010-0064573, filed on July 5, 2010 which is~~

~~hereby incorporated by reference for all purposes as if fully set forth herein. Also, when this application claims the priority benefit of the same Korean Patent Applications from countries in addition to the U.S., the disclosure will be incorporated herein by reference.~~

TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is the National Stage Entry of International Application No. PCT/KR2011/004835, filed on July 1, 2011, and claims priority from and the benefit of Korean Patent Application No. 10-2010-0064573, filed on July 5, 2010, all of which are hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND

[0002] FIELD

[0003] The present invention relates to a wireless communication system, and more particularly, to a wireless communication system that uses multiple input multiple output (MIMO) in both a transmitting end and a receiving end.

[0004] DISCUSSION OF THE BACKGROUND

[0005] As communication systems have developed, various wireless terminals have been utilized by consumers, such as companies and individuals.

[0006] A current mobile communication system, such as 3GPP, LTE (Long Term Evolution), LTE-A (LTE Advanced), and the like, may be a high capacity communication

system capable of transmitting and receiving various data such as image data, wireless data, and the like, beyond providing a sound-based service. Accordingly, there is a desire for a technology that transmits high capacity data, which is comparable with a wired communication network. Also, the system is required to minimize loss of information and increase transmission efficiency of the system so as to enhance performance of the system.

SUMMARY

[0007] In accordance with an aspect of the present invention, there is provided a communication method of a transmitting device including a first precoder and a second precoder, the method including: determining first information to restrict a precoding matrix from being used as a first precoding matrix of the first precoder, and second information to restrict a precoding matrix from being used as a second precoding matrix of the second precoder in a corresponding codebook with respect to each layer; and transmitting, to a receiving device, codebook restricting information including at least one of the determined first information and second information.

[0008] In accordance with another aspect of the present invention, there is provided a transmitting device, the device including: a layer mapper to map a codeword to a layer; a precoder including a first precoder and a second precoder that performs precoding on a data symbol corresponding to the codeword mapped to the layer by the layer mapper, using a first

precoding matrix and a second precoding matrix selected from a corresponding codebook; and an antenna array to transmit signals output from the precoder, and the codeword includes at least one of first information to restrict a precoding matrix from being used as the first precoding matrix and second information to restrict a precoding matrix from being used as the second precoding matrix in the corresponding codebook with respect to each layer.

[0009] In accordance with another aspect of the present invention, there is provided a communication method of a receiving device in a wireless communication system, the method including: receiving codebook restricting information including at least one of first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix for each layer; and transmitting, to a transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix being selected, based on the codebook restricting information, from among precoding matrices that are not restricted from being used as the first precoding matrix or the second precoding matrix in a codebook.

[0010] In accordance with another aspect of the present invention, there is provided a receiving device in a wireless communication system, the device including: an antenna array to receive, as codebook restricting information, at least one of first information to restrict a precoding matrix from being used as a first precoding matrix and first information to restrict a

precoding matrix from being used as a second precoding matrix with respect to each layer; and a channel information feedback device to transmit, to a transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix being selected, based on the codebook restricting information, from among precoding matrices that are not restricted from being used as the first precoding matrix of the second precoding matrix in a codebook.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a block diagram illustrating a wireless communication system according to embodiments of the present invention;

[0012] FIG. 2 is a diagram illustrating a wireless communication system in which a base station and a user equipment exchange codebook restricting information and channel status information in a case of codebook restriction;

[0013] FIG. 3 is a flowchart further illustrating a reference signal and signal transmission in the wireless communication system that exchanges codebook restricting information and channel status information of FIG. 2;

[0014] FIG. 4 is a block diagram illustrating a base station and a user equipment in a MIMO wireless communication system according to an embodiment of the present invention;

[0015] FIG. 5 is a diagram illustrating a channel between a base station and a user equipment that use a polarized antenna array of FIG. 4;

[0016] FIG. 6 is a flowchart illustrating a communication method of a transmitting device according to another embodiment of the present invention; and

[0017] FIG. 7 is a flowchart illustrating a communication method of a receiving device according to another embodiment of the present invention.

[0018] FIGS. 8 through 10 are conceptual diagrams illustrating a process of controlling inter-cell interference using a codebook restriction scheme in a wireless communication system according to embodiments of the present invention.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0019] Hereinafter, exemplary embodiments of the present invention will be described with reference to the accompanying drawings. In the following description, the same elements will be designated by the same reference numerals although they are shown in different drawings. Further, in the following description of the present invention, a detailed description of known functions and configurations incorporated herein will be omitted when it may make the subject matter of the present invention rather unclear.

[0020] FIG. 1 is a block diagram illustrating a wireless communication system according to embodiments of the present invention.

[0021] The wireless communication system may be widely installed so as to provide various communication services such as voice data, packet data, and the like.

[0022] Referring to FIG. 1, the wireless communication system may include a user equipment (UE) 10 and a base station (BS) 20.

[0023] The user equipment 10 may be an inclusive concept indicating a user terminal utilized in a wireless communication, including a UE (User Equipment) in WCDMA, LTE, HSPA, and the like, and an MS (Mobile Station), a UT (User Terminal), an SS (Subscriber Station), a wireless device and the like in GSM.

[0024] The base station 20 or a cell may generally refer to a station where communication with the user equipment 10 is performed, and may also be referred to as a Node-B, an eNB (evolved Node-B), a BTS (Base Transceiver System), an access point, a relay node, and the like.

[0025] In the specifications, the user equipment 10 and the base station 20 are used as two inclusive transceiving subjects to embody the technology and technical concepts described in the specifications, and may not be limited to a predetermined term or word.

[0026] An embodiment of the present invention may be applicable to an asynchronous wireless communication scheme that is advanced through GSM, WCDMA, and HSPA, to be LTE (Long Term Evolution) and LTE-advanced, and may be applicable to a synchronous wireless communication scheme that is advanced through CDMA and CDMA-2000, to be UMB.

Embodiments of the present invention may not be limited to a specific wireless communication scheme, and may be applicable to all technical fields to which a technical idea of the present invention is applicable.

[0027] The wireless communication system according to embodiments of the present invention may support an uplink and/or downlink HARQ (Hybrid Automatic Repeat request), and may use a CQI (channel quality indicator) for link adaptation. Also, a multiple access scheme for downlink transmission and a multiple access scheme for uplink transmission may be different from each other. For example, a downlink may use OFMDA (Orthogonal Frequency Division Multiple Access) and an uplink may use SC-FDMA (Single Carrier-Frequency Division Multiple Access).

[0028] To support high-speed information transmission for the user, the wireless communication system may consider using a Multiple Input Multiple Output (MIMO) scheme that transfers information through the same band using an antenna array including a multi-antenna.

[0029] To embody an effective MIMO system, a MIMO wireless communication system may need to provide, to a transmitting device, information associated with a propagation channel or information associated with a precoder or a precoding matrix (hereinafter referred to as a precoding matrix) appropriate for a propagation channel, to increase transmission capacity. In this example, the former requires a large amount of feedback overhead, whereas the latter

requires a relatively small amount of feedback overhead.

[0030] In the latter case, each of the user equipment 10 and the base station 20 stores a codebook that defines N available precoding matrices, and expresses an index or an indicator indicating or indexing (corresponding to) each precoding matrix, and identification. Each user equipment 10 selects a precoding matrix appropriate for a propagation channel, and transmits an index indexing the selected precoding matrix to the base station 20. The base station 20 receives precoding matrix indices from each user equipment 10, and selects a MIMO mode or a user equipment or performs precoding based on the received precoding matrix indices.

[0031] In this example, as a size of a codebook becomes larger since a number of available precoding matrices is large, the precoding performance of the base station 120 increases. However, an amount of feedback overhead of the user equipment 10 required for reporting the precoding matrices or corresponding indices to the base station 20 may be increased. Therefore, when a large size codebook is used, a codebook restriction or a codebook subset restriction that restricts at least one precoding matrix in a codebook may need to be used for more effective precoding.

[0032] The codebook restriction is a scheme that generates a codebook including various precoding matrices, selects a precoding matrix to be used/not used in the codebook for each cell or each user equipment, and uses different codebooks for each cell or each user equipment based on codebook restricting information (hereinafter referred to as "codebook restricting

information") associated with a precoding matrix to be not used. When the codebook restriction scheme is used, the whole wireless communication system has a large size codebook, but a codebook that is used by each cell or each user equipment is configured of subsets of the codebook, and has a small size, and is configured of only precoding matrices appropriate for a given environment and thus, a precoding gain may be increased.

[0033] For example, when downlink MIMO transmission between the base station 20 and the user equipment 10 simultaneously performs transmission with respect to up to 4 layers, the user equipment 10 may transfer, to the base station 20 using a rank indicator (RI), a number of layers that the user equipment 10 is capable of receiving. In this example, 16 precoding matrices may be designated for each rank during the downlink MIMO transmission between the base station 20 and the user equipment 10, and a total of 64 precoding matrices may be configured as shown in Table 1.

[0034] Table 1

RI \ PMI	0	1	2	·····	15
1	a0	a1	a2	·····	a15
2	a16	a17	a18	·····	a31
3	a32	a33	a34	·····	a47
4	a48	a49	a50	·····	a63

[0035] In a case in which the codebook restriction is used, when whether a precoding

matrix is to be used is determined for each of the 64 precoding matrices and codebook restricting information is transmitted based on a bitmap format that designates whether each precoding matrix is to be used using 1 bit, a total of 64 bits may be required. For example, a corresponding order of an available precoding matrix is expressed to be 1, and a corresponding order of an unavailable precoding matrix is expressed to be 0, as shown in [001010010……010].

[0036] The user equipment 10 may report, to the base station 20 as channel status information, 64 indices corresponding to the total of 64 precoding matrices using a total of 6 bits. In this example, when a codebook restriction that restricts the use of 32 precoding matrices from among the 64 precoding matrices is used, a number of information to be distinguished by 6 bits may be decreased from 64 to 32 and thus, a degree of reliability of a feedback signal may be increased. The user equipment 10 may decrease a number of bits that expresses the indices corresponding to the precoding matrices to 5 bits so as to reduce an amount of feedback overhead of the channel status information.

[0037] In addition, the use of precoding matrices that are predicted to cause inter-cell interference may be restricted by the codebook restriction and thus, the inter-cell interference may be prevented in advance. In particular, when a beamforming like precoding that is based on a location of each user equipment is performed, a user equipment located in a cell edge may cause serious inter-cell interference. To prevent the inter-cell interference in advance, a

codebook restriction may be performed for each cell and thus, the inter-cell interference may be controlled.

[0038] The base station 20 may use a multistage precoder including at least two precoders. The codebook restriction that restricts a precoding matrix to be used for each precoder may also be applicable, when the multistage precoder is used. In this example, a number of precoding matrices is generally increased and a number of bits to be used for codebook restricting information for the codebook restriction may also be increased.

[0039] In particular, a high signaling and feedback overhead may be required to support high speed information transmission in an uplink or a downlink and thus, a number of bits that the base station 20 uses to inform each user equipment 10 of the codebook restriction may need to be reduced.

[0040] The wireless communication system according to embodiments of the present invention has been described. Hereinafter, with reference to FIGS. 2 and 3, a process will be described in which a base station and a user equipment exchange codebook restricting information and channel status information in a wireless communication system when a multistage precoder is used in a case of codebook restriction.

[0041] FIG. 2 illustrates a wireless communication system in which a base station and a user equipment exchange codebook restricting information and channel status information in a case of codebook restriction.

[0042] Referring to FIG. 2, a wireless communication system 100 may include the base station 120 and may include at least one user equipment existing in the wireless communication system 100, for example, n user equipments 110, like the wireless communication system of FIG. 1. Although the user equipments 110 may correspond to user equipments that are currently being connected or that attempt additional connection, a single user equipment is illustrated in FIG. 2 for ease of descriptions.

[0043] The base station 120 includes a multistage precoder including at least two precoders, that is, first and second precoders. The base station 120 stores a first codebook 122 that expresses N first precoding matrices to be used for the first precoder and first indices indexing the first precoding matrices and a second codebook 124 that expresses M second precoding matrices to be used for the second precoder and second indices indexing the second precoding matrices.

[0044] The base station stores a restriction book 126 including ranks and an index (hereinafter referred to as a restriction index) corresponding to each pair of a first index and a second index with respect to each rank. The base station 120 determines a precoding matrix to be used/not used for each cell or for each user equipment, and may transmit, to the user equipment 110, codebook restricting information 128 associated with the precoding matrix to be not used. In this example, the codebook restricting information 128 includes first information that restricts a precoding matrix from being used as a first precoding matrix and second

information that restricts a precoding matrix from being used as a second precoding matrix in the first and second codebooks 122 and 124 with respect to each layer.

[0045] FIG. 3 is a flowchart further illustrating a reference signal and signal transmission in the wireless communication system that exchanges codebook restricting information and channel status information of FIG. 2.

[0046] Referring to FIG. 3, for transmission and reception of data between the user equipment 110 and the base station 120, the base station 120 at a transmitter side transmits a reference signal 130 as further illustrated in FIG. 3, and the user equipment 110 at a receiver side estimates a channel using the reference signal 130. For example, in a case of downlink transmission, the user equipment 110 may estimate a downlink channel. In particular, in a case of OFDM transmission, the user equipment 110 may estimate a channel of each subcarrier. Conversely, in a case of uplink transmission, the base station 120 may estimate an uplink channel.

[0047] For the channel estimation, a predetermined signal or symbol may be inserted into a frequency-domain grid at regular or irregular intervals. In this example, the predetermined signal or symbol may be referred to as a reference signal or a reference symbol, a pilot symbol, and the like. In the specifications, the predetermined signal or symbol is referred to as a reference signal, but this may not be limited thereto. The reference signal 130 may not be used for only the estimation of the frequency-domain channel, but may be used for estimation of a

location required for wireless communication between a user equipment and a base station, transmission and reception of control information, transmission and reception of scheduling information, transmission and reception of feedback information, and the like.

[0048] There may be various types of reference signals for downlink or uplink transmission, and new reference signals for various purposes have been defined and discussed. For example, reference signals for the uplink transmission may include a DM-RS (Demodulation RS), an SRS (Sounding RS), and the like. Reference signals for the downlink transmission may include a DM-RS (Demodulation RS), CRS (Cell-specific RS), an MBSFN RS, a UE-specific RS, and the like. Also, a CSI-RS is used as a reference signal that a base station transmits to obtain channel status information (CSI) of a center cell or adjacent cells from the user equipment 110 in a case of downlink transmission. The CSI-RS may be used for reporting a CQI (Channel Quality Indicator)/PMI (Precoder Matrix Indicator)/RI (Rank Indicator), and the like. The CSI-RS may be cell-specific so as to be distinguished for each cell included in a base station that transmits the CSI-RS, and may need to be sufficiently scattered in a frequency and a time for a low overhead.

[0049] Referring again to FIG. 2, the user equipment 110 stores a first codebook 112 that expresses N first precoding matrices used for a first precoder and first indices indexing the first precoding matrices and a second codebook 114 that expresses M second precoding matrices used for a second precoder and second indices indexing the second precoding matrices. The first

codebook 112 and the second codebook 114 may be identical to the first codebook 122 and the second codebook 124 stored in the base station 120, respectively.

[0050] The user equipment 110 stores a restriction book 116, which will be described with reference to Table 4, including ranks and a plurality of indices (hereinafter referred to as a restriction index) corresponding to each pair of a first index and a second index included in each rank. The restriction book 116 stored in each user equipment 110 may be identical to the restriction book 126 stored in the base station 120.

[0051] The user equipment 110 may receive codebook restricting information 128 from the base station 120. The codebook restricting information 128 includes at least one of first information that restricts a precoding matrix from being used as a first precoding matrix and second information that restricts a precoding matrix from being used as a second precoding matrix in first and second codebooks for each layer.

[0052] The user equipment 110 determines, based on the first information included in the codebook restricting information 128, a first precoding matrix excluding precoding matrices that are restricted from being used as a first precoding matrix, and reports/feeds back 1st channel status information 132 associated with the determined precoding matrix to the base station 120. Also, each user equipment 110 determines, based on the second information included in the codebook restricting information 128, a second precoding matrix excluding precoding matrices that are restricted from being used as a second precoding matrix, and reports/feeds back 2nd

channel status information 134 associated with the determined second precoding matrix to the base station 120.

[0053] The base station 120 determines precoding matrices of the first precoder and the second precoder from the first codebook 122 and the second codebook 124 based on the channel status information 132 and 134 reported from each user equipment 110, and performs precoding of data symbols using the precoding matrices.

[0054] Referring again to FIG. 3, the base station 120 transmits a precoded signal 136 to the user equipment 110 as illustrated in FIG. 3. Conversely, the user equipment 110 receives the signal 136 and decodes the signal into original data.

[0055] The process has been described in which a base station and a user equipment exchange codebook restricting information and channel status information in the wireless communication system when a multistage precoder is used in a case of codebook restriction. Hereinafter, a MIMO wireless communication system that transmits and receives codebook restricting information and the channel station information will be described.

[0056] FIG. 4 is a block diagram illustrating a base station and a user equipment in a MIMO wireless communication system according to an embodiment of the present invention. FIG. 5 illustrates a channel between a base station and a user equipment that uses a polarized antenna array of FIG. 4.

[0057] Referring to FIG. 4, a MIMO wireless communication system may include a user

equipment 410 and a base station 420.

[0058] The user equipment 410 includes an antenna array 411 to receive a signal through a downlink channel, a post-decoder 412 to process a received signal and to decode the received signal into original data using a precoding matrix, and a channel information feedback device 414.

[0059] The antenna array 411 may use a plurality of antennas. In this example, the antenna array 411 may form a polarized antenna array. The array may be embodied as a dual polarized antenna array in which two antennas having different polarities intersect each other so as to arrange a larger number of antennas in a limited space.

[0060] Referring to FIG. 5, when "+" indicates a direction polarizing to the right from the vertical direction and "-" indicates a direction polarizing to the left from the vertical direction, the user equipment 410 includes a polarized antenna array 411 including two pairs of antennas in which antennas 411aa and 411ab polarized at 45 degrees from the vertical direction and antennas 411ba and 411bb polarized at -45 degrees from the vertical direction intersect to each other, respectively. In this example, the antennas 411aa and 411ab polarized at +45 degrees may be referred to as a first domain 411a or a first subset of a transmitting side, and the antennas 411ba and 411bb polarized at -45 degrees may be referred to as a second domain 411b or a second subset of the transmitting side.

[0061] Referring again to FIG. 4, the post-decoder 412 may correspond to a first

precoder 422 and a second precoder 424 of the base station 420. The post-decoder may transfer a received reference signal to the channel information feedback device 414.

[0062] The channel information feedback device 414 may receive a reference signal and may estimate a channel using the reference signal. The channel information feedback device 414 may generate channel information including 1st channel status information and 2nd channel station information. The channel information feedback device 414 may feed back the channel information to the base station 420.

[0063] The base station 420 may include a layer mapper 421 to map a codeword to a layer, a precoder 425 to perform precoding of data symbols obtained through the layer mapping using a precoding matrix, and an antenna array 428 to transmit a precoded signal on air. The precoder 425 may include the first precoder 422 and the second precoder 424 to perform precoding of data symbols. In this example, the first precoder 422 and the second precoder 424 may perform precoding of data symbols using a corresponding first precoding matrix and a corresponding second precoding matrix, respectively.

[0064] The antenna array 428 of the base station 420 may use a plurality of antennas. In this example, the antenna array 428 may form a polarized antenna array. An array may be embodied as a dual polarized antenna array in which two antennas having different polarities intersect each other so as to arrange a larger number of antennas in a limited space in a wireless communication system. In this example, although it is described that the antenna arrays 411 and

428 use a dual polarized antenna array, this may not be limited thereto.

[0065] Referring to FIG. 5, the base station 420 includes a polarized antenna array 428 including four pairs of antennas in which antennas 428aa through 428ad polarized at 45 degrees from the vertical direction and antennas 428ba through 428bd polarized at -45 degrees intersect each other, respectively. In this example, the antennas 428aa through 428ad polarized at +45 degrees are referred to as a first domain 428a or a first subset of a receiving side, and the antennas 428ba through 428bd polarized at -45 degrees are referred to as a second domain 428b or a second subset of a receiving side.

[0066] When a phase mismatch does not exist between polarized antennas of the user equipment 410 and the base station 420, an overall channel H may be expressed as shown in Equation 1.

[0067] Equation 1

$$H = \begin{bmatrix} H_h & 0 \\ 0 & H_v \end{bmatrix}$$

[0068] In this example, H_h denotes a channel between the first subset or the first domain 411a of the user equipment 410 and the first subset or the first domain 428a of the base station 420, and H_v denotes a channel between the second subset or the second domain 411b and the second subset or the second domain 428b of the base station 420.

[0069] As shown in Equation 1, when antennas polarized to different directions intersect each other and have no phase mismatch, the antennas may not affect each other. Therefore, only H_h and H_v may be estimated and thus, a channel may be recognized. When a distance d between adjacent polarized antennas is shorter than a signal wavelength λ, a correlation between antennas may be high. In this example, H_h and H_v may be determined based on a distance d between antennas and an incident angle θ of signal propagation that arrives at the user equipment 410.

[0070] When a phase mismatch exists between polarized antennas of the user equipment 410 and the base station 420, for example, when pairs of antennas of the user equipment 410 are tilted to the left by ε, signals transmitted from each polarized domain of the base station 420 may be received by two polarized domains of the user equipment 410 and thus, inter-domain interference may occur due to a phase mismatch between the domains. Therefore, a channel may be affected by a degree of a phase error or a phase mismatch between polarized antennas of the user equipment 410 and the base station 420, that is, by ε, and thus, the overall channel H may be expressed by Equation 2.

[0071] Equation 2

$$H = \begin{bmatrix} H_h \cos\varepsilon & -H_v \sin\varepsilon \\ H_h \sin\varepsilon & H_v \cos\varepsilon \end{bmatrix}$$

[0072] Referring again to FIG. 4, the second precoder 424 may correct a phase mismatch to remove an effect from a phase error or a phase mismatch between polarized domains formed by the antenna array 428 including antennas intersecting in a horizontal direction and a vertical direction, and the first precoder may perform intra-domain precoding.

[0073] When a dual polarized domain is configured based on a scheme of arranging two antennas at the same location, each polarized domain may have an identical spatial channel characteristic. That is, each domain may be precoded based on an identical precoding matrix ($H_h = H_v = R_0$), and a signal transmitted through each polarized domain may have a different phase and size when arriving at the user equipment 410. In this example, a first precoding matrix and a second precoding matrix used in the first precoder 422 and the second precoder 424 may be expressed by Equation 3.

[0074] Equation 4

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

[0075] In Equation 3, R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

[0076] A size of a signal received in each domain may be determined by a precoding gain of R_0 of a first precoding matrix W_1, a second precoding matrix W_2 corrects a phase mismatch between signals received in respective domains. When an operation proceeds in this manner, a first index PMI_1 for setting the first precoding matrix W_1 and a second index PMI_2 for setting the second precoding matrix W_2 may be independently selected.

[0077] As shown in Equation 3, the precoder 425 is a precoder configured of a first precoding matrix that performs precoding using R_0 determined by a precoding gain in each of the two domains (a polarized domain or a subset of antennas) and a second precoding matrix that performs phase mismatch correction (co-phasing) between domains. Therefore, each of the two independent domains may be precoded by R_0 determined by a precoding gain, and one of the domains may be phase-corrected by $\wedge$ and may be transmitted.

[0078] In the precoder 425, the second precoding matrix corresponds to a precoding matrix that corrects signal attenuation caused by a phase error between polarized domains in polarized antennas. Also, the second precoding matrix may correspond to a precoding matrix to correct signal attenuation caused by a phase error between polarized domains, or may correspond to a precoding matrix to correct a phase mismatch that naturally occurs between polarized antennas. The base station 420 stores a first codebook that expresses N (N is a natural number greater than or equal to 1) first precoding matrices used for the first precoder 422 and first indices indexing the first precoding matrices, and a second codebook that expresses M (M is a

natural number greater than or equal to 1) second precoding matrices and second indices indexing the second precoding matrices.

[0079] Table 2 and Table 3 correspond to examples of the first codebook and the second codebook that use 16 precoding matrices and 4 precoding matrices for each rank, respectively, when the antenna array 428, including 8 dual polarized antennas 428a and 428b, simultaneously transmits a total of 8 layers.

[0080] Table 2

RI \ PMI_1	0	1	2	.....	15
1	b0	b1	b2	.....	b15
2	b16	b17	b18	.....	b31
.....	.....	.....	.....	.....	.....
8	b112	b113	b114	.....	b127

[0081] Table 3

RI \ PMI_2	0	1	2	3
1	c0	c1	c2	c3
2	c4	c5	c6	c7
.....	.....	.....	.....	.....
8	c28	c29	c30	c31

[0082] The base station 420 stores a restriction book including ranks and an index

(hereinafter referred to as a restriction index) corresponding to each pair of a first index and a second index for each rank. Table 4 corresponds to a restriction book that uses 16 precoding matrices and 4 precoding matrices for each rank when the antenna array 428, including 8 dual polarized antennas 428a and 428b, simultaneously transmits a total of 8 layers.

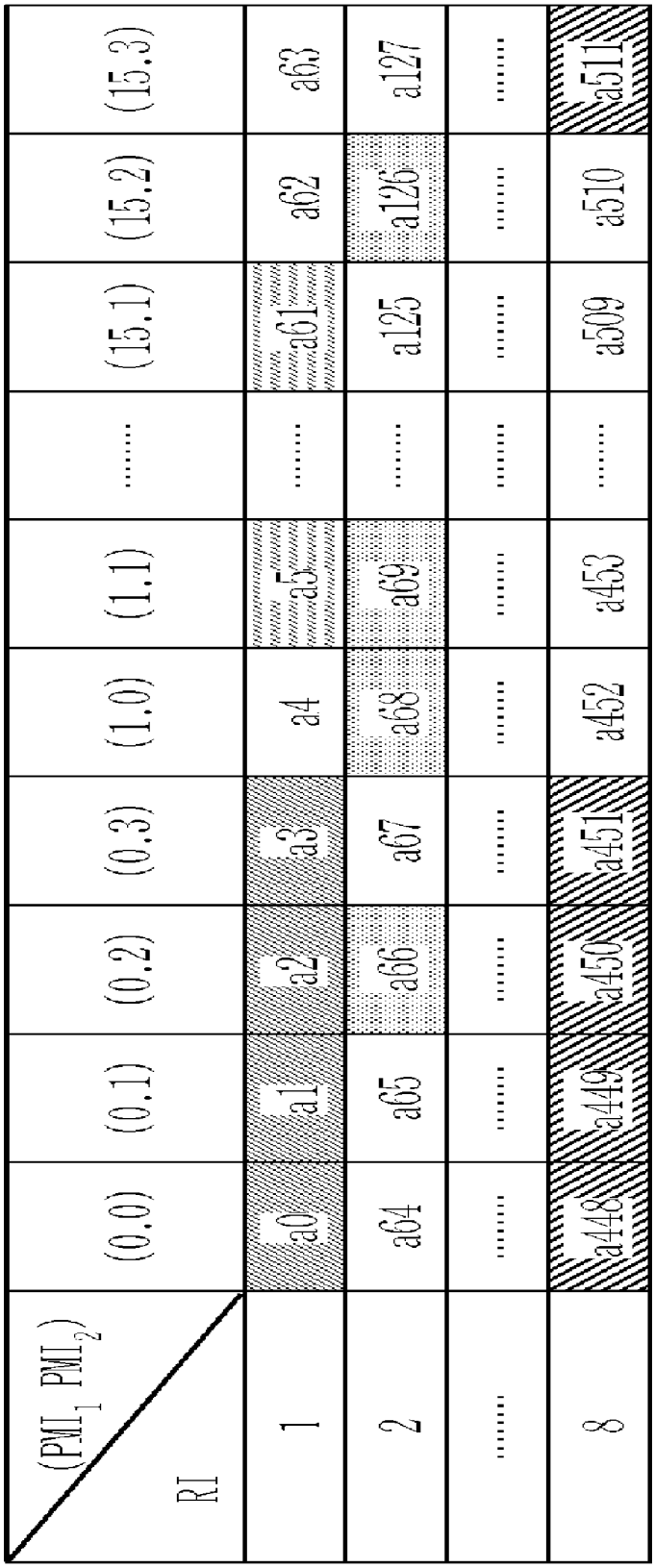
[0083] Table 4

RI \ (PMI_1, PMI_2)	(0.0)	(0.1)	(0.2)	(0.3)	(1.0)	(1.1)	.....	(15.1)	(15.2)	(15.3)
1	a0	a 1	a 2	a 3	a4	a5	.....	a61	a62	a63
2	a64	a65	a66	a67	a68	a69	.....	a125	a126	a127
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	a448	a449	a450	a451	a452	a453	.....	a509	a510	a511

[0084] In a case of codebook restriction, when codebook restricting information is transmitted based on a bitmap format that designates whether each precoding matrix is to be used using one bit, a total of 16x4x8=512 bits may be required for the ranks and pairs of a first index and a second index for respective ranks.

[0085] However, as described in the foregoing, a first index PMI_1 for setting a first precoding matrix W_1 and a second index PMI_2 for setting a second precoding matrix W_2 may be independently selected and thus, a codebook may be restricted independently with respect to each precoding matrix, for each rank and for each of the first precoder and the second precoder. Table 5 expresses precoders that are restricted in a restriction book when codebook restriction is determined with respect to the first index=0 (PMI_1=0) and the second index=1 (PMI_2=1) in a rank 1.

[0086] Table 6



RI \ (PMI_1, PMI_2)	(0,0)	(0,1)	(0,2)	(0,3)	(1,0)	(1,1)	.....	(15,1)	(15,2)	(15,3)
1	a0	a1	a2	a3	a4	a5	.....	a61	a62	a63
2	a64	a65	a66	a67	a68	a69	.....	a125	a126	a127
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	a448	a449	a450	a451	a452	a453	.....	a509	a510	a511

[0087] Although not illustrated in Table 5, a codebook restriction may be independently performed on a first precoding matrix and a second precoding matrix with respect to 8 ranks, in the same manner as the codebook restriction performed on the rank 1.

[0088] The base station 420 determines a precoding matrix to be used/not used for each cell or for each user equipment, and transmits codebook restricting information associated with the precoding matrix to be not used to the user equipment 410. In this example, the codebook restricting information may include first information that restricts a precoding matrix from being used as a first precoding and second information that restricts a precoding matrix from being used as a second precoding matrix in the first and second codebooks for each layer.

[0089] As shown in Table 5, when codebook restriction on a first index=0 (PMI_1=0) and a second index=1 (PMI_2=1) is determined with respect to the rank 1, codebook restricting information may include $[0111111111111111]$ corresponding to first information and $[1011]$ corresponding to second information in a bitmap format. As described in the foregoing, a corresponding order of an available precoding matrix is expressed to be 1, and a corresponding order of a precoding matrix not to be used is expressed to be 0. Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=0 (PMI_1=0), for example, (PMI_1, PMI_2) = (0,1), (0,1), (0, 2), (0,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=1 (PMI_2=1), for example, (PMI_1, PMI_2) = (0,1), (1,1), …, (14,1), (15,1) in table 5.

[0090] When a codebook restriction on a first index=1 (PMI_1=1) and a second index=2 (PMI_2=2) is determined with respect to a rank 2, codebook restricting information may include $[1011111111111111]$ corresponding to first information and $[1101]$ corresponding to second information. Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=1 (PMI_1=1), for example, (PMI_1, PMI_2) = (1,1), (1,1), (1,2), (1,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=2 (PMI_2=2), for example, (PMI_1, PMI_2) = (0,2), (1,2), …, (14,2), (15,2) in table 5.

[0091] When a codebook restriction on a first index=0 (PMI_1=0) and a second index=3 (PMI_2=3) is determined with respect to a rank 8, codebook restricting information may include $[0111111111111111]$ corresponding to first information and $[1110]$ corresponding to second information. Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=0 (PMI_1=0), for example, (PMI_1, PMI_2) = (0,1), (0,1), (0, 2), (0,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=3 (PMI_2=3), for example, (PMI_1, PMI_2) = (0,3), (1,3), …, (14,3), (15,3) in table 5.

[0092] In other words, the codebook restricting information includes the first information and the second information. Accordingly, when a first precoding matrix is restricted from being used as a first precoding matrix based on the first information, the use of second precoding

matrices that make pairs with the restricted first precoding matrix may be restricted. When a second precoding matrix is restricted from being used as a second precoding matrix based on the second information, the use of first precoding matrices that make pairs with the restricted second precoding matrix may be restricted.

[0093] In the same manner, codebook restricting information with respect to each of a rank 3 through a rank 7 may include first information and second information in a bitmap format. In this example, although the codebook restricting information including the first information and the second information is provided in a bitmap format, this is merely an example and may not be limited thereto.

[0094] In the same manner described in the foregoing, when the rank 1 through rank 8 transmit codebook restricting information based on the same bitmap format, a total number of bits of the codebook restricting information that independently restricts a first precoding matrix and a second precoding matrix with respect to a total of 8 ranks may be $(16 + 4) \times 8 = 160$.

[0095] The base station 420 may transmit, to the user equipment 410, codebook restricting information that expresses codebook restriction based on a bitmap format using 20 bits for each rank, that is, a total of 160 bits for the rank 1 through the rank 8. The codebook restricting information may be transmitted as downlink control information, for example, an RRC signal, from the base station 420 to the user equipment 410 through a Physical Downlink Shared Channel (PDSCH). In this example, the codebook restricting information may be

transmitted from the base station 420 to the user equipment 410 through a Physical Downlink Control Channel (PDCCH) in addition to the PDSCH. In this example, the codebook restricting information may sequentially include first information and second information for each rank. For example, the codebook restricting information may include first information and second information associated with the rank 1, first information and second information associated with the rank 2,…, and first information and second information associated with the rank 8, sequentially.

[0096] The codebook restricting information may sequentially include first information for each rank, and then may sequentially include second information for each rank. For example, the codebook restricting information may sequentially include first information associated with the rank 1 through the rank 8, and then may sequentially include second information associated with the rank 1 through the rank 8. The first information and the second information included in the codebook restricting information may be independently transmitted for each rank from the base station 420 to the user equipment 410. When a codebook is not restricted for a predetermined rank, codebook restricting information associated with the predetermined codebook may not be included.

[0097] Accordingly, when a pair of a first index and a second index is restricted, codebook restricting information of a total of 512 bits is required. However, when restriction on a first index and a second index is independently determined and transmitted, an amount of

feedback overhead of the codebook restriction may be significantly reduced.

[0098] When the first precoder 422 performs intra-domain precoding using a first precoding matrix, for example, in a case where a codebook is restricted so that precoding matrices expressed to be a first index=7 (PMI_1=7) are not to be used since an intra-domain precoding gain is small, any precoding matrix that is expressed to be PMI_1=7 when the second precoder 424 performs phase mismatch correction using a second precoding matrix may not obtain an excellent precoding gain.

[0099] That is, determining restriction on a first precoding matrix that performs intra-domain precoding may take precedence over determining restriction on a second precoding matrix that performs phase mismatch correction. Therefore, when a codebook restriction is performed, only the first precoding matrix may be restricted. In this example, the codebook restricting information includes only first information that restricts the first precoding matrix and thus, a total of 16 x 8= 128 bits may be required.

[0100] When inter-domain phase mismatch interference takes precedence in a condition of the same inter-domain interference, only the second precoding matrix may be restricted. In this example, the codebook restricting information includes only second information that restricts the second precoding matrix and thus, a total of 4 x 8 = 32 bits may be required.

[0101] As described in the foregoing, a scheme that restricts both the first precoding matrix and the second precoding matrix, independently, a scheme that restricts only the first

precoding matrix, and a scheme that restricts only the second precoding matrix may be selectively used. In this example, the base station 420 may transmit, to the user equipment 410, a restriction mode indicator of a total of 2 bits that indicates a restriction mode.

[0102] The channel information feedback device 414 of the user equipment 410 determines a first precoding matrix excluding precoding matrices that are restricted from being used as a first precoding matrix based on first information included in codebook restricting information, and reports/feeds back, to the base station 420, 1st channel status information associated with the first precoding matrix. In the example provided in the foregoing, when [0111111111111111] corresponding to first information of a bitmap format that restricts a codebook with respect to a first index = 0 (PMI_1=0) in a rank 1 is received, the channel information feedback device 414 determines a first precoding matrix from among precoding matrices corresponding to indices excluding the first index=0 (PMI_1=0), that is, from among precoding matrices excluding precoding matrices corresponding the first index=0, and reports/feeds back 1st channel status information associated with the first precoding matrix to the base station. Also, each user equipment 410 determines a second precoding matrix excluding matrices that are restricted from being used as a second precoding matrix based on second information included in codebook restricting information, and reports/feeds back, to the base station 420, 2nd channel status information associated with the second precoding matrix. In the example provided in the foregoing, when [1011] corresponding to second information of a

bitmap format that restricts a codebook with respect to a second index =1 (PMI_2=1) in a rank 2 is received, the channel information feedback device 414 determines a second precoding matrix from among precoding matrices corresponding to indices excluding the second index=1 (PMI_2=1), that is, from among precoding matrices excluding precoding matrices corresponding to the second index=1, and reports/feeds back 2nd channel status information associated with the second precoding matrix to the base station.

[0103] When [1011111111111111] corresponding to first information and [1101] corresponding to second information of a bitmap format that restrict a codebook with respect to a first index=1 (PMI_1=1) and a second index=2 (PMI_2=2) in the rank 2 are received, the channel information feedback device 414 determines a first precoding matrix and a second precoding matrix excluding precoding matrices corresponding to the first index=1 (PMI_1=1) and the second index=2 (PMI_2=2) with respect to the rank 2 as shown in Table 5, and reports/feeds back, to the base station, the associated 1st channel status information and 2nd channel status information. In the same manner, the channel information feedback device 414 may determine a first precoding matrix and a second precoding matrix excluding precoding matrices designated by first information and second information, with respect to the rank 3 through the rank 8.

[0104] As described in the foregoing, a scheme that restricts both the first precoding matrix and the second precoding matrix, independently, a scheme that restricts only the first precoding matrix, and a scheme that restricts only the second precoding matrix may be

selectively used. When the base station 420 transmits, to the user equipment 410, a restriction mode indicator of a total of 2 bits that indicates a restriction mode, the channel information feedback device 414 of the user equipment 410 may determine a first precoding matrix and a second precoding matrix based on the restriction mode, and generates and reports 1st channel status information and 2nd channel status information.

[0105] A feedback period or interval of the 1st channel status information and the 2nd channel status information may be different from each other. For example, the 1st channel status information may be fed back to the base station 420 based on a short term, and the 2nd channel status information may be fed back to the base station 420 based on a long term. In other words, a long period/long term and a short period/short term are relative terms, and the long period/long term indicates a period that is longer than the short period/short term.

[0106] The first precoder 422 and the second precoder 424 of the base station 420 determine first and second precoding matrices based on/using channel status information reported from each user equipment 410, and perform precoding of data symbols using the precoding matrices.

[0107] The MIMO wireless communication system that transmits and receives codebook restricting information and channel status information according to another embodiment of the present invention has been described. Hereinafter, a communication method of a transmitting device according to another embodiment of the present invention will be described.

[0108] FIG. 6 is a flowchart illustrating a communication method of a transmitting device according to another embodiment of the present invention.

[0109] Referring to FIG. 6, a communication method 600 of a transmitting device according to another embodiment of the present invention includes a layer mapping step S610 to map a codeword to a layer, a precoding step S620 to perform precoding of symbols, and a transmitting step S630 to propagate a precoded symbol into air through two or more antennas. The layer mapping step S610, the precoding step S620, and the transmitting step S630 are identical as described in the foregoing and thus, detailed descriptions thereof will be omitted.

[0110] A communication method 600 of a base station according to another embodiment of the present invention independently performs codebook restriction on a first precoding matrix of Table 3 and a second precoding matrix of Table 4 with respect to each rank by referring to Table 5, and transmits, to the user equipment 410, codebook restricting information that expresses codebook restriction in a bitmap format using 20 bits for each rank, that is, a total of 160 bits from a rank 1 through a rank 8. The codebook restricting information may be transmitted as downlink control information, for example, an RRC signal, from the base station 420 to the user equipment 410 through a Physical Downlink Shared Channel (PDSCH). In this example, the codebook restricting information may be transmitted from the base station 420 to the user equipment 410 through another channel such as a Physical Downlink Control Channel (PDCCH) in addition to the PDSCH.

[0111] In the layer mapping step S610, the codebook restricting information may be mapped to a layer as a downlink control signal.

[0112] The base station 420 determines a precoding matrix to be used/not to be used for each cell or each user equipment, and transmits codebook restricting information associated with the precoding matrix to the user equipment 410. In this example, the codebook restricting information includes first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix in first and second codebooks for each layer.

[0113] As shown in Table 5, when codebook restriction is determined with respect to a first index=0 (PMI_1=0) and a second index=1 (PMI_2=1) in a rank 1, codebook restricting information may include $[0111111111111111]$ corresponding to first information and $[1011]$ corresponding to second information in a bitmap format.

[0114] The precoding step S620 may perform precoding of a data symbol obtained through layer mapping, using a first precoding matrix and a second precoding matrix selected from a corresponding codebook. In this example, the precoding step S620 may perform precoding of data symbols using a first precoding matrix and a second precoding matrix corresponding to a first index and a second index received from a receiving device such as a user equipment. In this example, the first index and the second index received from the receiving device may correspond to indices associated with precoding matrices selected from precoding

matrices excluding precoding matrices that are restricted based on the codebook restricting information in the first codebook of Table 3 and the second codebook of Table 4.

[0115] As described in the foregoing, the transmitting device such as a base station may include at least one antenna pair in which at least one antenna polarized in one direction and at least one antenna polarized in another direction intersect each other.

[0116] In this example, as described with reference to Equation 3, a first precoding matrix performs precoding between one antenna and another antenna that intersect each other, and a second precoding matrix performs phase mismatch correction between one antenna and another antenna.

[0117] The communication method of the transmitting device has been described. Hereinafter, a communication method of a receiving device will be described.

[0118] FIG. 7 is a flowchart illustrating a communication method of a receiving device according to another embodiment of the present invention.

[0119] A communication method 700 of a receiving device may include a codebook restricting information receiving step S710 to receive codebook restricting information from a transmitting device, and a channel information transmitting step S720 to transmit 1st channel status information and 2nd channel status information to the transmitting device.

[0120] The codebook restricting information receiving step S710 may receive first information to restrict a precoding matrix from being used as a first precoding matrix and second

information to restrict a precoding matrix from being used as a second precoding matrix for each layer. In this example, the codebook restricting information includes first information to restrict a precoding matrix from being used as a first precoding matrix and second information to restrict a precoding matrix from being used as a second precoding matrix in a first codebook and a second codebook for each layer. The channel information transmitting step S720 transmits, to the transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix, the first precoding matrix and the second precoding matrix being selected, based on codebook restricting information, from precoding matrices that are not restricted from being used as a first precoding matrix or a second precoding matrix in a codebook.

[0121] Step S710 and step S720 will be described in detail in the following. When the receiving device receives [0111111111111111] corresponding to first information and [1011] corresponding to second information in a bitmap format that restrict a codebook with respect to a first index=0 (PMI_1=0) in a rank 1 in step S710, the receiving device determines a first precoding matrix from among precoding matrices corresponding to indices excluding the first index=0 (PMI_1=0), that is, from among precoding matrices excluding precoding matrices corresponding to the first index=0, as shown in Table 5, and reports/feeds back associated 1st channel status information to a base station, and determines a second precoding matrix from among precoding matrices corresponding to indices excluding the second index=1 (PMI_2=1),

that is, from among precoding matrices excluding precoding matrices corresponding to the second index = 1, and reports/feeds back associated 2nd channel status information to the base station in step S720.

[0122] Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=0 (PMI_1=0), for example, (PMI_1, PMI_2) = (0,1), (0,1), (0, 2), (0,3) in Table 5. Also, a codebook may be generally restricted with respect to the first indices that make pairs with the second index=1 (PMI_2=1), for example, (PMI_1, PMI_2) = (0,1), (1,1), …, (14,1), (15,1) in table 5.

[0123] When the receiving device receives [1011111111111111] corresponding to first information and [1101] corresponding to second information of a bitmap format that restrict a codebook with respect to a first index = 1 (PMI_1=1) and a second index = 2 (PMI_2=2) in a rank 2 in step S710, the receiving device determines a first precoding matrix and a second precoding matrix excluding precoding matrices corresponding to the first index = 1 (PMI_1=1) and the second index = 2 (PMI_2=2) for the rank 2 as shown in Table 5, and reports/feeds back associated 1st channel status information and associated 2nd channel status information to the base station in step S720.

[0124] Accordingly, a codebook may be generally restricted with respect to second indices that make pairs with the first index=1 (PMI_1=1), for example, (PMI_1, PMI_2) = (1,1), (1,1), (1, 2), (1,3) in Table 5. Also, a codebook may be generally restricted with respect to the

first indices that make pairs with the second index=2 (PMI_2=2), for example, (PMI_1, PMI_2) = (0,2), (1,2), …, (14,2), (15,2) in table 5.

[0125] In other words, the codebook restricting information includes the first information and the second information. Accordingly, when a first precoding matrix is restricted from being used as a first precoding matrix based on the first information, the use of second precoding matrices that make pairs with the restricted first precoding matrix may be restricted. When a second precoding matrix is restricted from being used as a second precoding matrix based on the second information, the use of first precoding matrices that make pairs with the restricted second precoding matrix may be restricted.

[0126] In the same manner, the receiving device may determine a first precoding matrix and a second precoding matrix for each of a rank 3 through a rank 8, excluding precoding matrices designated by first information and second information.

[0127] The process in which a base station and a user equipment exchange codebook restricting information and channel status information in a wireless communication system when a codebook is restricted in a case where a multistage precoder is used, a MIMO wireless communication system that transmits and receives codebook restricting information and channel status information, and the transceiving method or communication method of the transmitting device and the receiving device in the wireless communication system have been described.

[0128] According to the embodiments of the present invention, information to restrict

precoding matrices is determined for each multistage precoder, and codebook restricting information including the determined information is transmitted and thus, an amount of transmission overhead of the codebook restricting information may be reduced. According to the embodiments of the present invention, the wireless communication system uses the codebook restriction scheme and thus, inter-cell interference may be controlled.

[0129] According to a definition of a precoding matrix as described with reference to Equation 3, a precoding gain in each domain or a subset of an antenna is determined by a first precoding matrix. That is, an overall precoding gain is determined by a gain associated with the first precoding matrix and a coding gain of a second precoder matrix that performs phase mismatch correction (co-phasing) between domains or subsets. In this example, the second precoding matrix performs phase mismatch correction (co-phasing) between domains or subsets and thus, a maximum precoding gain that each user equipment is able to obtain may be determined by the first precoding matrix. In other words, power or receivable maximum power of a signal that each user equipment receives is determined by a first precoder or a first precoding matrix, and a second precoder or a second precoding matrix performs only phase correction of a signal received by each domain or subset of an antenna. Interference by multiple-access may be significantly affected by a first precoder or a first precoding matrix.

[0130] FIGS. 8 through 10 are conceptual diagrams illustrating a process of controlling inter-cell interference using a codebook restriction scheme in a wireless communication system

according to embodiments of the present invention.

[0131] Referring to FIG. 8, inter-cell interference may occur among cell edge user equipments 810a through 810d during beamforming. For example, user equipments 810a and 810b exist in a coverage of a first base station and a second base station as shown in FIG. 8 and thus, when a signal is transmitted that is precoded based on a first precoding matrix associated with a PMI_1=4 or PMI_1=6 of the first base station of a first cell 820a, transmission of a signal that is precoded based on a first precoding matrix associated with a PMI_1=13 of the second base station or a second cell 820b may cause interference.

[0132] In other words, the user equipments 810a and 810b receive both the transmitted signal that is precoded based on the first precoding matrix associated with the PMI_1=4 or PMI_1=6 of the first base station or the first cell 820a and the transmitted signal that is precoded based on the first precoding matrix associated with a PMI_1=13 of the second base station or the second cell 820b and thus, interference may occur.

[0133] Also, user equipments 810c and 810d exist in a coverage of the first base station and the second base station as shown in FIG. 8 and thus, when a signal is transmitted that is precoded based on a first precoding matrix associated with a PMI_1=8 of the first base station 820a, transmission of a signal that is precoded based on a first precoding matrix associated with a PMI_1=2 or a PMI_1=11 of the second base station 820b may cause interference.

[0134] The descriptions may be specifically provided using the user equipment 810b as

an example as follows. The user equipment 810b receives a signal from both the first base station 820a and the second base station 820b as shown in FIG. 8. The first base station 820a transmits a signal using the first precoding matrix corresponding to the PMI_1=6 to transmit a signal to the user equipment 810b, and the second base station 820b uses the first precoder matrix corresponding to the PMI_1=13 to transmit a signal to the user equipment 810b. Accordingly, as illustrated in FIG. 8, when the second base station 820b transmits a signal to the user equipment 810b using the PMI_1=13, another user equipment 810a may receive multiple-access interference by the signal transmitted to the user equipment 810b.

[0135] When the second base station 820b restricts a codebook so that the first precoder matrix corresponding to the PMI_1=13 is not to be used, the user equipment 810b receives a signal from only the first base station 820a and thus, inter-cell interference due to multiple-interference may be prevented in advance.

[0136] Other user equipments 810c and 810d may receive multiple-access interference due to inter-cell interference, like the user equipments 810a and 810b.

[0137] When the first base station 820a restricts a codebook so that the first precoder matrix corresponding to the PMI_1=8 is not to be used, user equipments 810c and 810d receive a signal from only the second base station 820b and thus, inter-cell interference due to multiple-interference may be prevented in advance.

[0138] FIG. 9 conceptually illustrates a case in which a first precoding matrix or an

associated index that is expected to cause inter-cell interference is restricted by performing a codebook restriction based on the above-mentioned scheme, and a downlink MIMO is performed based on the restriction.

[0139] Referring to FIG. 9, when each base station 820a and 820b performs a PMI_1=13 based codebook restriction that restricts the use of a first precoding matrix corresponding to a PMI_1=13 or a PMI_1=8, occurrence of inter-cell interference may be avoided or reduced as illustrated in FIG. 9. Therefore, when a codebook restriction is applied to only a PMI_1 and is not applied to a PMI_2, inter-cell interference may be removed.

[0140] Referring to FIG. 10, the user equipment 810b receives signals precoded based on a first precoding matrix associated with a PMI_1=6 of a first base station and a first precoding matrix associated with a PMI_1=13 of a second base station and thus, interference may occur. The user equipment 810c receives signals precoded based on a first precoding matrix associated with a PMI_1=8 of the first base station and a first precoding matrix associated with a PMI_1=2 of the second base station and thus, interference may occur. In this example, the first base station may allow the use of the PMI_1=6 and may restrict the use of the PMI_1=2, and conversely, the second base station may allow the use of the PMI_1=2 and may restrict the use of the PMI_1=6 and thus, interference between user equipments may be removed.

[0141] As another example, to remove interference between user equipments, the first base station may allow the use of the PMI_1=8 and may restrict the use of the PMI_1=13, and

conversely, the second base station may allow the use of the PMI_1=13 and may restrict the use of the PMI_1=8.

[0142] As another example, to remove interference between user equipments, the first base station may allow the use of the PMI_1=6 and the PMI_1=8 and the second base station may restrict the use of the PMI_1=6 and the PMI_1=8. Conversely, the first base station may restrict the use of the PMI_1=6 and the PMI_1=8 and the second base station may allow the use of the PMI_1=6 and the PMI_1=8.

[0143] As described in the foregoing, when each base station 820a and 820b performs the PMI_1 based codebook restriction, occurrence of inter-cell interference may be avoided or reduced.

[0144] Also, when codebook restriction is applied with respect to only the PMI_2, there is an advantage in that a codebook is restricted by a small number of bits. Also, no restriction is applied to the PMI_1 that directly controls a precoding gain and thus, more precise precoding is available and a size of a codebook may be reduced.

[0145] Although the embodiments of the present invention have been described in detail, the present invention may not be limited thereto.

[0146] The embodiments of the present invention may be applied to an up/downlink MIMO system, and may be applied to all up/downlink MIMO systems such as a Coordinated multi-point transmission/reception system (CoMP), a heterogeneous network, and the like, in

addition to a single cell environment.

[0147] Although a preferred embodiment of the present invention has been described for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims. Therefore, the embodiments disclosed in the present invention are intended to illustrate the scope of the technical idea of the present invention, and the scope of the present invention is not limited by the embodiment. The scope of the present invention shall be construed on the basis of the accompanying claims in such a manner that all of the technical ideas included within the scope equivalent to the claims belong to the present invention.

Electronic Patent Application Fee Transmittal

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Filing Date:	
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First Named Inventor/Applicant Name:	Kyoungmin PARK
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Natl Stage Search Fee - Report provided	1642	1	500	500
National Stage Exam - all other cases	1633	1	250	250
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Natl Stage Appl Sz fee per 50 pgs >100	1681	2	320	640
Claims:				
Claims in excess of 20	1615	11	62	682
Independent claims in excess of 3	1614	1	250	250

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
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8	Drawings-only black and white line drawings	P5158US00_Drawings.pdf	138766 ff966b20ad8e1d911ae36c7aaf747b54067f814a	no	10
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9	Oath or Declaration filed	P5158US00_Executed_Declaration.pdf	221026 cd51022962c2e8bea7358932a61a89bdfe4a7632	no	1
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11		P5158US00_Preliminary_Amendment.pdf	20480 c5edd40f1c190d488c5234aca5ecb4d340df517a	yes	3

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0-7	**출원인 또는 대리인의 서류참조기호**	**PCT11-354**
I	**발명의 명칭**	**송신장치 및 그 통신방법, 수신장치, 그 통신방법**
II	**출원인**	
II-1	이 사람은	오직 출원인
II-2	우측 지정국에 관한 출원인	미국을 제외한 모든 지정국
II-4ko	성명	**(주)팬택**
II-4en	Name:	**PANTECH CO.,LTD.**
II-5ko	주소	서울시 마포구 상암동 **DMC, I-2,** 팬택빌딩 **121-270** 대한민국
II-5en	Address:	**Pantech Bldg., I-2, DMC, Sangam-dong, Mapo-gu,** **Seoul, 121-270** **Republic of Korea**
II-6	국적	대한민국 **KR**
II-7	거주국	대한민국 **KR**
II-8	전화번호	**+82-2-2030-0114**
II-9	팩스번호	**+82-2-2030-2521**
II-10	이메일 주소	**kwon.hyukjoon@pantech.com**
II-11	출원인 코드	**1-1998-004053-1**

PCT 출원서

출력(전자적 형태가 원본)

III-1	**출원인 및/또는 발명자**	
III-1-1	이 사람은	출원인 겸 발명자
III-1-2	우측 지정국에 관한 출원인	오직 미국만
III-1-4ko	성명	박경민
III-1-4en	Name (LAST, First):	**PARK, Kyoungmin**
III-1-5ko	주소	서울시 마포구 상암동 **DMC, I-2,** 팬택빌딩 **121-270** 대한민국
III-1-5en	Address:	**Pantech Bldg., I-2, DMC, Sangam-dong, Mapo-gu, Seoul, 121-270** **Republic of Korea**
III-1-6	국적	대한민국 **KR**
III-1-7	거주국	대한민국 **KR**
IV-1	**대리인 또는 대표자** 아래에 기재된 자는 관할 국제기관에 대하여 우측에 표시된 자격으로 출원인을 대리하는 것으로 선임되었다.	대리인 **(agent)**
IV-1-1ko	성명	김은구
IV-1-1en	Name (LAST, First):	**KIM, Eungu**
IV-1-2ko	주소	서울특별시 강남구 역삼동 **636-15** 상원빌딩 **2**층 **135-908** 대한민국
IV-1-2en	Address:	**2F, Sangwon Bld., 636-15 Yeoksam-dong, Gangnam-gu, Seoul, 135-908** **Republic of Korea**
IV-1-3	전화번호	**+82-2-568-6177**
IV-1-4	팩스번호	**+82-2-568-6176**
IV-1-5	이메일 주소	**ip@highestip.com**
IV-1-5(a)	이메일 사용동의 수리관청, 국제조사기관, 국제사무국, 국제예비심사기관이 필요 시 이 이메일 주소를 사용하여 이 국제 출원과 관련하여 발행된 통지서를 송부할 것에 동의한다.	서면 통지서에 앞서 선람용 사본 송부
IV-1-6	대리인 코드	**9-1999-000318-1**
IV-2	**추가 대리인**	최초 기재된 대리인과 동일한 주소를 갖는 새로운 대리인(들)
IV-2-1ko	성명	송, 해모**(9-2002-000179-4)**
IV-2-1en	Name(s)	**SONG, Haemo(9-2002-000179-4)**

PCT 출원서

출력(전자적 형태가 원본)

V	지정국		
V-1	**본 출원서의 제출로, 규칙 4.9(a)에 따라, 부여될 수 있는 모든 종류의 권리 보호를 위하여, 그리고 해당하는 경우 지역특허 및 국내특허 모두를 위하여 당해 국제출원일에 PCT에 기속되는 모든 체약국이 지정된다.**		
V-2	**V-2란은 출원서 제출시 또는 규칙 26의2.1에 의해 그 이후 출원서 제6기재란에 위 특정 관련 체약국의 국내 선출원에 대한 우선권주장이 포함되어 있을 경우 당해 체약국의 국내법에 의해 해당 국내 선출원의 효력이 상실되는 것을 방지하기 위한 목적으로 당해 체약국의 지정을 제외하는 데에만 사용될 수 있다 (지정 제외시 이의 취소 불가능).**	**KR**	
VI-1	**선국내출원에 대한 우선권 주장**		
VI-1-1	출원일	**2010년 07월 05일 (05.07.2010)**	
VI-1-2	출원번호	**10-2010-0064573**	
VI-1-3	국가	**KR**	
VI-2	**우선권 주장 요청** 수리관청에 대하여 위에 명시된 선출원의 인증등본을 준비하여 국제사무국에 송부하여 줄 것을 신청한다.	**VI-1**	
VI-3	**인용에 의한 보완** 조약 제11조(1)(iii)(d) 또는 (e)에서 규정하는 국제출원의 요소, 또는 규칙 20.5(a)에서 규정하는 명세서, 청구 범위 또는 도면의 일부가 본 국제출원에는 포함되어 있지 않지만 조약 제11조(1)(iii) 규정의 요소 중 하나 이상이 수리관청에 최초로 접수된 날에 우선권주장의 기초가 된 선출원에 완전히 포함되어 있는 경우, 그 요소 또는 부분은 규칙 20.6 규정에 의한 확인을 조건으로, 규칙 20.6의 규정과 관련하여 본 국제출원에 있어서 인용에 의해 보완된다.		
VII-1	**국제조사기관(ISA) 선택**	**대한민국 특허청 (ISA/KR)**	
VIII	**선언서**	선언서 개수	
VIII-1	발명자의 동일성에 관한 선언	-	
VIII-2	국제출원일에 특허출원 및 특허를 받을 수 있는 출원인의 자격에 관한 선언	-	
VIII-3	국제출원일에 선출원의 우선권을 주장할 수 있는 출원인의 자격에 관한 선언	-	
VIII-4	발명자 선언(미국에 대한 지정의 경우에 한함)	-	
VIII-5	신규성을 해치지 아니하는 개시 또는 신규성 상실의 예외에 관한 선언	-	
IX	**체크 리스트**	용지 수	전자적 파일 첨부
IX-1	출원서(선언서 포함)	**4**	✓
IX-2	명세서	**22**	✓
IX-3	청구범위	**6**	✓
IX-4	요약서	**1**	✓
IX-5	도면	**9**	✓
IX-7	용지매수 소계	**42**	

PCT 출원서

출력(전자적 형태가 원본)

	첨부 항목	서면 첨부	전자적 파일 첨부
IX-8	수수료 계산 용지	-	✓
IX-11	포괄위임장 사본	-	✓
IX-18	PCT-SAFE 전자출원 매체	-	-
IX-20	**요약서에 수반되어야 할 도면 번호**	**3**	
IX-21	국제출원의 출원 언어	한국어	
X-1	출원인, 대리인 또는 대표자의 서명 또는 날인	**(PKCS7 전자서명)**	
X-1-1	성명	김 은구	
X-1-2	서명인의 성명		
X-1-3	권한		

수리관청 전용

10-1	국제출원으로 제출된 서류의 실제 접수일	**2011년 07월 01일 (01.07.2011)**
10-2	도면	
10-2-1	접수	
10-2-2	미접수	
10-3	국제출원으로 제출된 서류를 완성하는 서류 또는 도면의 추후 기간내 제출에 따른 정정된 실제 접수일	
10-4	PCT 제11조(2)에 따라 제출이 요구된 보완서로서 기간내 제출된 보완서의 접수일	
10-5	국제조사기관(ISA)	**ISA/KR**
10-6	조사료 납부시까지 지연된 조사용 사본의 송부	

국제 사무국 전용

11-1	국제 사무국의 기록원본 접수일	



별첨 사본은 아래 출원의 원본과 동일함을 증명함.

This is to certify that the following application annexed hereto is a true copy from the records of the Korean Intellectual Property Office

출 원 번 호 : 10-2010-0064573
Application Number

출 원 년 월 일 : 2010년 07월 05일
Filling Date JUL 05, 2010

출 원 인 : 주식회사 팬택
Applicant(s) PANTECH CO.,LTD.

2011 년 07 월 11 일

특 허 청
COMMISSIONER

2010-07-05

【서지사항】

【서류명】 특허출원서

【출원구분】 특허출원

【출원인】

【명칭】 주식회사 팬택

【출원인코드】 1-1998-004053-1

【대리인】

【성명】 송해모

【대리인코드】 9-2002-000179-4

【포괄위임등록번호】 2005-094061-4

【대리인】

【성명】 김은구

【대리인코드】 9-1999-000318-1

【포괄위임등록번호】 2009-049482-2

【발명의 국문명칭】 송신장치 및 그 통신방법, 수신장치, 그 통신방법

【발명의 영문명칭】 Transmitter and Communicating method thereof, Receiver, Communicating method thereof

【발명자】

【성명】 박경민

【성명의 영문표기】 PARK, Kyoung Min

【주민등록번호】 770630-1XXXXXX

【우편번호】 411-440

【주소】 경기도 고양시 일산서구 가좌동 푸르지오 206-501

【국적】 KR

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2010-07-05

【취지】 위와 같이 특허청장에게 제출합니다.

대리인 송해모 (서명 또는 인)

대리인 김은구 (서명 또는 인)

【수수료】

【출원료】	0	면	38,000 원
【가산출원료】	60	면	0 원
【우선권주장료】	0	건	0 원
【심사청구료】	0	항	0 원
【합계】	38,000 원		

【명세서】

【발명의 명칭】

송신장치 및 그 통신방법, 수신장치, 그 통신방법{Transmitter and Communicating method thereof, Receiver, Communicating method thereof }

【기술분야】

<1> 본 명세서는 무선통신시스템에 관한 것으로서, 송수신단 모두에서 다중입력 다중출력 안테나(MIMO)를 이용하는 무선통신시스템에 관련된 것이다.

【배경기술】

<2> 통신 시스템이 발전해나감에 따라 사업체들 및 개인들과 같은 소비자들은 매우 다양한 무선 단말기들을 사용하게 되었다.

<3> 현재의 3GPP, LTE(Long Term Evolution), LTE-A(LTE Advanced)등의 무선통신 시스템은 음성 위주의 서비스를 벗어나 영상, 무선 데이터 등의 다양한 데이터를 송수신 할 수 있는 고속 대용량의 통신 시스템으로서, 유선 통신 네트워크에 준하는 대용량 데이터를 전송할 수 있는 기술 개발이 요구되고 있을 뿐 아니라, 정보 손실의 감소를 최소화하고, 시스템 전송 효율을 높임으로써 시스템 성능을 향상시킬 필요가 있었다.

【발명의 내용】

【해결하려는 과제】

<4> 일 실시예는, 무선통신시스템에서, 제1프리코더와 제2프리코더를 포함하는

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송신장치에서, 상기 자신의 코드북에서 각 레이어에 대해 상기 제1프리코더의 제1 프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코더의 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 각각 결정하는 단계 및 결정한 상기 제1정보와 상기 제2정보 중 적어도 하나를 포함하는 코드북제한정보를 수신장치에 전송하는 단계를 포함하는 송신장치의 통신방법을 제공할 수 있다.

<5> 또다른 측면에서 다른 실시예는 코드워드를 레이어에 매핑하는 레이어 맵퍼 상기 코드워드가 상기 레이어 맵퍼에 의해 상기 레이어에 매핑된 데이터심볼을 자신의 코드북에서 선택한 제1프리코딩 행렬과 제2프리코딩 행렬을 이용하여 프리코딩하는 제1프리코더와 제2프리코더를 포함하는 프리코더 프리코더로부터 출력된 신호들을 전송하는 안테나 어레이를 포함하며, 상기 코드워드는, 상기 코드북에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하는 송신장치를 제공할 수 있다.

<6> 또다른 측면에서 또다른 실시예는 무선통신시스템에서, 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하는 코드북제한정보로 각각 수신하는 수신단계 및 상기 코드북제한정보를 이용하여 상기 코드북에서 상기 제1프리코딩 행렬 또는 상기 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송하는 전송단계를 포함하는 수신

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장치의 통신방법을 제공할 수 있다.

<7> 또다른 측면에서 또다른 실시예는 무선통신시스템에서, 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제1정보 중 적어도 하나를 코드북제한정보로 각각 수신하는 안테나 어레이와, 코드북제한정보를 이용하여 코드북에서 제1프리코딩 행렬 또는 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송하는 채널정보 피드백장치를 포함하는 수신장치를 제공할 수 있다.

【도면의 간단한 설명】

<8> 도 1은 실시예들이 적용되는 무선 통신 시스템을 개략적으로 나타낸 도면이다.

도 2는 코드북제한시 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 무선통신시스템을 도시하고 있다.

도 3은 도 2의 코드북제한정보와 채널상태정보를 교환하는 무선통신시스템에서 참조신호와 신호 전송을 추가로 표시한 흐름도이다.

도 4는 MIMO 무선통신시스템에서 일실시예에 따른 기지국과 단말 각각의 구성도이다.

도 5는 도 4의 편파 안테나 어레이를 사용하는 기지국과 단말 사이 채널을

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도시하고 있다.

도 6은 또다른 실시예에 따른 송신장치의 통신방법의 흐름도이다.

도 7은 또다른 실시예에 따른 수신장치의 통신방법의 흐름도이다.

【발명을 실시하기 위한 구체적인 내용】

<9> 이하, 본 발명의 일부 실시예들을 예시적인 도면을 통해 상세하게 설명한다. 각 도면의 구성요소들에 참조부호를 부가함에 있어서, 동일한 구성요소들에 대해서는 비록 다른 도면상에 표시되더라도 가능한 한 동일한 부호를 가지도록 하고 있음에 유의해야 한다. 또한, 본 발명을 설명함에 있어, 관련된 공지 구성 또는 기능에 대한 구체적인 설명이 본 발명의 요지를 흐릴 수 있다고 판단되는 경우에는 그 상세한 설명은 생략한다.

<10> 또한, 본 발명의 구성 요소를 설명하는 데 있어서, 제 1, 제 2, A, B, (a), (b) 등의 용어를 사용할 수 있다. 이러한 용어는 그 구성 요소를 다른 구성 요소와 구별하기 위한 것일 뿐, 그 용어에 의해 해당 구성 요소의 본질이나 차례 또는 순서 등이 한정되지 않는다. 어떤 구성 요소가 다른 구성요소에 "연결", "결합" 또는 "접속"된다고 기재된 경우, 그 구성 요소는 그 다른 구성요소에 직접적으로 연결되거나 또는 접속될 수 있지만, 각 구성 요소 사이에 또 다른 구성 요소가 "연결", "결합" 또는 "접속"될 수도 있다고 이해되어야 할 것이다.

<11> 도 1은 실시예들이 적용되는 무선통신시스템을 도시한다.

<12> 무선통신시스템은 음성, 패킷 데이터 등과 같은 다양한 통신 서비스를 제공

하기 위해 널리 배치된다.

<13> 도 1을 참조하면, 무선통신시스템은 단말(10; User Equipment, UE) 및 기지국(20; Base Station, BS)을 포함한다.

<14> 본 명세서에서의 단말(10)은 무선 통신에서의 사용자 단말을 의미하는 포괄적 개념으로서, WCDMA 및LTE, HSPA 등에서의 UE(User Equipment)는 물론, GSM에서의 MS(Mobile Station), UT(User Terminal), SS(Subscriber Station), 무선기기(wireless device) 등을 모두 포함하는 개념으로 해석되어야 할 것이다.

<15> 기지국(20) 또는 셀(cell)은 일반적으로 단말(10)과 통신하는 고정된 지점(fixed station)을 말하며, 노드-B(Node-B), eNB(evolved Node-B), BTS(Base Transceiver System), 액세스 포인트(Access Point), 릴레이 노드(Relay Node) 등 다른 용어로 불릴 수 있다

<16> 즉, 본 명세서에서 기지국(20) 또는 셀(cell)은 CDMA에서의 BSC(Base Station Controller), WCDMA의 NodeB 등이 커버하는 일부 영역을 나타내는 포괄적인 의미로 해석되어야 하며, 메가셀, 매크로셀, 마이크로셀, 피코셀, 펨토셀 및 릴레이 노드(relay node) 통신범위 등 다양한 커버리지 영역을 모두 포괄하는 의미이다.

<17> 본 명세서에서 단말(10)과 기지국(20)은 본 명세서에서 기술되는 기술 또는 기술적 사상을 구현하는데 사용되는 두가지 송수신 주체로 포괄적인 의미로 사용되며 특정하게 지칭되는 용어 또는 단어에 의해 한정되지 않는다.

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<18> 무선통신시스템에 적용되는 다중 접속 기법에는 제한이 없다. CDMA(Code Division Multiple Access), TDMA(Time Division Multiple Access), FDMA(Frequency Division Multiple Access), OFDMA(Orthogonal Frequency Division Multiple Access), OFDM-FDMA, OFDM-TDMA, OFDM-CDMA와 같은 다양한 다중 접속 기법을 사용할 수 있다.

<19> 상향링크 전송 및 하향링크 전송은 서로 다른 시간을 사용하여 전송되는 TDD(Time Division Duplex) 방식이 사용될 수 있고, 또는 서로 다른 주파수를 사용하여 전송되는 FDD(Frequency Division Duplex) 방식이 사용될 수 있다.

<20> 일실시예는 GSM, WCDMA, HSPA를 거쳐 LTE(Long Term Evolution) 및 LTE-advanced로 진화하는 비동기 무선통신과, CDMA, CDMA-2000 및 UMB로 진화하는 동기식 무선 통신 분야의) 등에 적용될 수 있다. 본 발명은 특정한 무선통신 분야에 한정되거나 제한되어 해석되어서는 아니되며, 본 발명의 사상이 적용될 수 있는 모든 기술분야를 포함하는 것으로 해석되어야 할 것이다.

<21> 실시예들이 적용되는 무선통신시스템은 상향링크 및/또는 하향링크 HARQ를 지원할 수 있으며, 링크 적응(link adaptation)을 위해 CQI(channel quality indicator)를 사용할 수 있다. 또한, 하향링크와 상향링크 전송을 위한 다중 접속 방식은 서로 다를 수 있으며, 예컨데, 하향링크는 OFDMA(Orthogonal Frequency Division Multiple Access)를 사용하고, 상향링크는 SC-FDMA(Single Carrier-Frequency Division Multiple Access)를 사용할 수 있는 것과 같다.

<22> 무선통신시스템은 사용자에게 고속 정보 전송을 지원하기 위해서 다중 안테

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나를 포함하는 안테나 어레이를 사용하여 동일 대역을 통해 정보를 전달하는 다중 입력 다중 출력(Multiple Input Multiple Output, MIMO) 기법의 사용을 고려하고 있다.

<23> 한편, 효과적인 MIMO 시스템 구현을 위해, MIMO 무선통신시스템은 전송 용량 증대를 위해 전파 채널에 대한 정보 또는 전파 채널에 적합한 프리코더 또는 프리코딩 행렬(이하 프리코딩 행렬이라 함)에 대한 정보를 전송장치에 제공하여야 한다. 이때 전자는 큰 피드백 오버헤드를 요구하는 반면, 후자는 상대적으로 적은 피드백 오버헤드를 요구한다.

<24> 후자의 경우 각 단말(10)과 기지국(20)은 사용 가능한 N개의 프리코딩 행렬들을 한정하고 각 프리코딩 행렬을 표시하는 또는 인덱싱하는(에 대응하는) 인덱스 또는 인디케이터, 식별표시를 표현하는 코드북을 저장한다. 각 단말(10)은 전파 채널에 적합한 프리코딩 행렬을 선정하고, 선정한 프리코딩 행렬을 인덱싱하는 인덱스를 기지국(20)에 송신한다, 기지국(20)은 각 단말(10)로부터 프리코딩 행렬 인덱스들을 수신하고, 이들을 이용하여 MIMO 모드나 단말 선정, 프리코딩을 수행한다.

<25> 이때 사용 가능한 프리코딩 행렬들의 수가 많아 코드북의 크기가 클수록 기지국(120)의 프리코딩 성능은 증가하나 프리코딩 행렬 또는 그 인덱스를 기지국(20)에 보고하기 위한 단말(10)의 피드백 오버헤드는 증가할 수 있다. 따라서, 보다 효과적인 프리코딩을 위해 큰 크기 코드북(large size codebook)을 사용하되 코드북에서 적어도 하나의 프리코딩 행렬을 제한하는 코드북제한(codebook

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restriction) 또는 코드북 서브세트 제한(codebook subset restriction)을 사용할 수 있다.

<26> 코드북제한(codebook restriction)은 다양한 프리코딩 행렬들을 포함하는 코드북을 생성한 후 코드북에서 각 셀(cell) 단위 또는 사용자(User Equipment) 단위로 사용할/사용하지 않을 프리코딩 행렬을 선정하고 사용하지 않을 프리코딩 행렬에 대한 코드북제한정보(이하, "코드북제한정보"라 함)를 통해 각 셀 단위 또는 사용자 단위로 다른 코드북을 사용하는 기법이다. 이 코드북제한 기법의 사용시 무선통신시스템 전체는 큰 크기의 코드북을 가지지만 각 셀 또는 각 사용자가 사용하는 코드북은 코드북의 서브세트로 구성되어 크기가 작으면서 주어진 환경에 적합한 프리코딩 행렬만으로 구성되어 프리코딩 게인을 증가시킬 수 있다.

<27> 예를 들어 기지국(20)과 단말(10) 사이 하향링크 MIMO 전송시 최대 4개의 레이어들로 동시 전송할 수 있는 경우, 단말(10)은 자신이 수신할 수 있는 레이어의 수를 랭크 지시자(Rank Indicator, RI)를 사용하여 기지국(20)에 전달할 수 있다. 이 경우 기지국(20)과 단말(10) 사이 하향링크 MIMO 전송시 각 랭크당 16개의 프리코딩 행렬들을 지정하여 총 64개의 프리코딩 행렬들로 표 1과 같이 코드북을 구성할 수 있다.

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<28> 【표 1】

PMI / RI	0	1	2	……	15
1	a0	a1	a2	……	a15
2	a16	a17	a18	……	a31
3	a32	a33	a34	……	a47
4	a48	a49	a50	……	a63

<29> 코드북 제한시 64개의 프리코딩 행렬들 각각에 대하여 사용 여부를 결정하고 프리코딩 행렬들 각각의 사용여부를 한비트를 이용하여 지정하는 비트맵 형식으로 코드북제한정보를 전송할 경우 총 64비트가 필요할 수 있다. 예를 들어 [001010010 …….010]와 같이 사용할 수 있는 프리코딩 행렬에 대해선 해당 순서에 1로 표시하고 사용하지 않을 프리코딩 행렬에 대해선 해당 순서에 0으로 표시할 수 있다.

<30> 한편, 단말(10)은 채널상태정보로 총 64개의 프리코딩 행렬들에 대응하는 64개의 인덱스들을 총 6비트를 사용하여 기지국(10)에 보고할 수 있다. 이때 총 64개의 프리코딩 행렬들 중 32개의 프리코딩 행렬들의 사용을 제한하는 코드북제한시 6비트로 구분해야 하는 정보의 수가 64에서 32로 감소하여 피드백 신호의 신뢰도를 증가시킬 수 있다. 한편, 단말(10)은 프리코딩 행렬들에 대응하는 인덱스들을 표현하는 비트수를 5비트로 줄여 채널상태정보의 피드백 오버헤드를 줄일 수도 있다.

<31> 아울러, 코드북 제한을 사용하여 셀간 간섭(Inter-cell interference)을 발생시킬 것이라 예상되는 프리코딩 행렬들의 사용을 제한하여 셀간 간섭의 발생을

사전에 방지할 수도 있다. 특히 각 단말의 위치에 기반한 빔 형성 기반 프리코딩(beam-forming like precoding)을 수행할 경우, 셀 경계(cell edge)에 위치한 단말은 심각한 셀 간 간섭을 발생시킬 수 있다. 이를 사전에 방지하기 위하여 셀 별 코드북 제한을 수행하여 셀 간 간섭을 제어할 수 있다.

<32> 기지국(20)은 적어도 두개의 프리코더들을 포함하는 다단 구조의 프리코더를 사용할 수 있다. 다단 구조의 프리코더를 사용할 경우도 각 프리코더에 사용하는 프리코딩 행렬을 제한하는 코드북제한을 사용할 수 있다. 이 경우 전체적으로 프리코딩 행렬들의 수가 증가하며 코드북제한을 위해 사용하는 코드북제한정보를 위해 사용되는 비트수도 증가할 수 있다.

<33> 특히, 상향링크 또는 하향링크에서 고속 정보 전송을 지원하기 위해 높은 시그널링과 피드백 오버헤드를 사용해야 하기 때문에, 기지국(20)이 각 단말(10)에코드북 제한을 알리기 위해 사용하는 비트수도 줄일 필요가 있다.

<34> 이상 실시예들이 적용되는 무선통신시스템을 설명하였으나 이하 도 2 및 도3을 참조하여 다단 구조의 프리코더를 사용할 경우 코드북제한시 무선통신시스템에서 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 과정을 기재한다.

<35> 도 2는 코드북제한시 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 무선통신시스템을 도시하고 있다.

<36> 도 2를 참조하면, 무선통신시스템(100)은 도 1의 무선통신시스템과 동일하게 기지국(120)과 기지국(120) 내에 존재하는 적어도 하나의 단말, 예를 들어 n개의

단말들(110)을 포함할 수 있다. 이 단말들(110)은 현재 접속되어 있거나 추가 접속을 시도하는 단말들일 수 있으나 도 2에는 하나의 단말만을 표시한다.

<37> 기지국(120)은 후술하는 바와 같이 적어도 두개의 제1및 제2프리코더들을 포함하는 다단 구조의 프리코더를 포함하고 있다. 기지국(120)은 제1프리코더에 사용되는 N개의 제1프리코딩 행렬들과 이들을 인덱싱하는 제1인덱스들을 표현하는 제1코드북(122)과 제2 프리코더에 사용되는 M개의 제2프리코딩 행렬들과 이들을 인덱싱하는 제2인덱스들을 표현하는 제2코드북(124)을 저장하고 있다.

<38> 기지국(120)은 랭크들과 랭크들 각각에 대한 제1인덱스들 각각과 제2인덱스들 각각의 쌍에 대응하는 인덱스(이하, 제한 인덱스라 함)를 포함하는 제한북(126, restriction book)을 저장하고 있다. 기지국(120)은 각 셀(cell) 단위 또는 사용자(User Equipment) 단위로 사용할/사용하지 않을 프리코딩 행렬을 결정하고 사용하지 않을 프리코딩 행렬에 대한 코드북제한정보(128)를 단말(110)에 전송할 수 있다. 이때 코드북제한정보(128)는 제1 및 제2코드북들(122, 124)에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 포함하고 있다.

<39> 도 3은 도 2의 코드북제한정보와 채널상태정보를 교환하는 무선통신시스템에서 참조신호와 신호 전송을 추가로 표시한 흐름도이다.

<40> 도 3을 참조하면, 단말(110)과 기지국(120) 사이 데이터를 송수신하기 위해 송신자 측 기지국(120)은 도 3에 추가로 도시한 바와 같이 참조신호(230)를 전송하고, 수신자 측 단말(receiver side, 110)은 이 참조신호(130)를 이용하여 채널을

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추정할 수 있다. 예를 들어, 하향링크 전송시 단말(110)은 하향링크 채널을 추정할 수 있다. 특히 OFDM 전송시 단말(110)은 각 서브캐리어의 채널을 추정할 수 있다. 반대로, 상향링크 전송시 기지국(120)은 상향링크 채널을 추정할 수 있다.

<41> 채널의 추정을 위해 주파수-도메인 그리드 내에 규칙 또는 불규칙한 간격으로 특정 신호 또는 심볼을 삽입할 수 있다. 이때 이 특정 신호 또는 심볼을 참조신호(reference signal) 또는 참조심볼(reference symbol), 파일롯 심볼(pilot symbol) 등 다양하게 명명하나 본 명세서에서는 이 특정 신호 또는 심볼을 참조신호라 하나 그 용어에 제한되지 않는다. 물론 참조신호(130)는 주파수 도메인 채널의 추정에만 사용되지 않고 단말과 기지국 사이의 무선통신 과정에서 필요한 위치추정, 제어정보의 송수신, 스케줄링정보의 송수신, 피드백정보의 송수신 등을 위해서 사용될 수도 있다.

<42> 하향링크 또는 상향링크 전송시 각각 여러 종류의 참조신호들이 존재하며 다양한 용도로 새로운 참조신호들이 정의되고 있으며 논의되기도 한다. 예를 들어 상향링크 전송시 참조신호로 DM-RS(Demodulation RS), SRS(Sounding RS) 등이 있다. 하향링크 전송시 참조신호로 DM-RS(Demodulation RS), CRS(Cell-specific RS), MBSFN RS, UE-specific RS 등이 있다. 또한, 하향링크 전송시 단말(20)에서 중심 셀 또는 인접 셀들의 채널상태정보(Channel State Information(CSI))를 획득하기 위하여 기지국에서 전송하는 참조신호로 CSI-RS가 있다. 이 CSI-RS는 CQI(Channel Quality Indicator)/PMI(Precoder Matrix Index)/RI(Rank Index) 등을 리포팅하는데 사용될 수 있다. 이 CSI-RS는 CSI-RS를 전송하는 기지국에 포함된 각

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셀마다 서로 구분가능하도록 셀-특화(Cell-specific)되며 낮은 오버헤드를 위해 주파수와 시간에서 충분히 산재해야 한다.

<43> 다시 도 2를 참조하면, 단말(110)은 제1프리코더에 사용되는 N개의 제1프리코딩 행렬들과 이들을 인덱싱하는 제1인덱스들을 표현하는 제1코드북(112)과 제2프리코더에 사용되는 M개의 제2프리코딩 행렬들과 이들을 인덱싱하는 제2인덱스들을 표현하는 제2코드북(114)을 저장하고 있다. 제1코드북(112)와 제2코드북(114)는 각각 기지국(120)가 저장하고 있는 제1코드북(122)와 제2코드북(124)와 동일하다.

<44> 단말(110)은 랭크들과 랭크들 각각에 속하는 제1인덱스 및 제2인덱스 쌍에 대응한 복수의 인덱스들(이하, 제한 인덱스라 함)을 포함하는 표 4를 참조하여 후술할 제한북(116)을 저장하고 있다. 각 단말(110)이 저장하고 있는 제한북(116)은 기지국(120)이 저장하고 있는 제한북(126)과 동일하다.

<45> 단말(110)은 기지국(120)으로부터 전술한 코드북제한정보(128)를 수신할 수 있다. 이 코드북제한정보(128)는 제1 및 제2코드북들에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하고 있다.

<46> 단말(110)은 코드북제한정보(128)에 포함된 제1정보에 따라 제1프리코딩 행렬로 사용되는 것이 제한된 프리코딩 행렬들을 제외하고 제1프리코딩 행렬을 결정하고 그 제1프리코딩 행렬에 대한 제1채널상태정보(132)를 기지국(120)에 보고/피드백할 수 있다. 또한, 각 단말(110)은 코드북제한정보(128)에 포함된 제2정보에

따라 제2프리코딩 행렬로 사용되는 것이 제한된 프리코딩 행렬들을 제외하고 제2프리코딩 행렬을 결정하고 그 제2프리코딩 행렬에 대한 제2채널상태정보(134)를 기지국(120)에 보고/피드백할 수 있다.

<47> 기지국(120)은 각 단말(110)로부터 보고받은 채널상태정보들(132, 134)을 기초로 이용하여 제1코드북(122)와 제2코드북(124)에서 제1프리코더와 제2프리코더의 프리코딩 행렬들을 결정하고 그 프리코딩 행렬들을 이용하여 데이터심볼들을 프리코딩한다.

<48> 다시 도 3을 참조하면, 최종적으로 기지국(120)은 도 3에 추가로 도시한 바와 같이 프리코딩된 신호(136)를 단말(110)에 전송한다. 반대로 단말(110)은 이 신호(136)을 수신한 후 원 데이터를 디코딩한다.

<49> 이상 다단 구조의 프리코더를 사용할 경우 코드북제한시 무선통신시스템에서 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 과정을 설명하였으나 코드북제한정보와 채널생태정보를 송수신하는 MIMO 무선통신시스템에 대해 상세히 기재한다.

<50> 도 4는 MIMO 무선통신시스템에서 일실시예에 따른 기지국과 단말 각각의 구성도이다. 도 5는 도 4의 편파 안테나 어레이를 사용하는 기지국과 단말 사이 채널을 도시하고 있다.

<51> 도 4을 참조하면, MIMO 무선통신시스템(400)은 단말(410)과 기지국(420)을 포함할 수 있다.

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<52> 단말(410)은 하향링크 채널을 통해 신호를 수신하는 안테나 어레이(411)와 수신한 신호를 처리하고 프리코딩 행렬을 이용하여 원래의 데이터 심볼로 디코딩하는 포스트 디코더(post-decoder, 412), 채널정보 피드백장치(414)를 포함한다.

<53> 안테나 어레이(411)는 다수의 안테나들을 사용할 수 있다. 이때 안테나 어레이(411)은 편파 안테나 어레이를 형성할 수도 있다. 무선통신시스템에서 한정된 공간에 보다 많은 안테나들을 배열하기 위해 서로 다른 편파를 가지는 두 개의 안테나들을 교차하여 설치한 이중 편파 안테나 어레이(dual polarized antenna array)를 사용하여 어레이를 구현할 수도 있다.

<54> 도 5를 참조하면, 수직방향을 기준으로 오른쪽으로 편파된 것으로 "+"로 표시하고 왼쪽으로 편파된 것을 "-"로 표시할 때 단말(410)은 수직방향을 기준으로 45도로 편파된 하나의 안테나들(411aa 내지 411ad)와 -45도로 편파된 다른 안테나(411ba 내지 411bd)가 서로 직교하는 안테나쌍 두개를 포함하는 편파 안테나 어레이(411)를 포함하고 있다. 이때 +45도로 편파된 안테나들(411aa 내지 411ad)은 송신측 제1서브세트 또는 제1도메인(411a)이라 할 수 있고 -45도로 편파된 다른 안테나들(411ba 내지 411bd)은 송신측 제2서브세트 또는 제2도메인이라고 할 수 있다.

<55> 다시 도 4를 참조하면, 포스트 디코더(412)는 기지국(420)의 제1프리코더(422)와 제2프리코더(424)에 대응된다. 포스트 디코더(412)는 수신한 참조신호를 채널정보 피드백장치(414)에 전달한다.

<56> 채널정보 피드백장치(414)는 참조신호를 수신하고 이 참조신호를 이용하여

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채널을 추정할 수 있다. 채널정보 피드백장치(414)는 제1채널상태정보와 제2채널상태정보를 포함하는 채널정보를 생성할 수 있다. 채널정보 피드백장치(414)는 이 채널정보를 기지국(420)에 피드백할 수 있다.

<57> 기지국(420)은 코드워드를 레이어에 맵핑하는 레이어 맵퍼(421)와 레이어 매핑된 데이터 심볼들을 프리코딩 행렬을 이용하여 프리코딩하는 포함하는 프리코더(425), 프리코딩된 신호를 공중으로(on air)으로 전송하는 안테나 어레이(428)를 포함한다. 프리코더(425)는 데이터 심볼들을 프리코딩하는 제1프리코더(422)와 제2프리코더(424)를 포함할 수 있다. 이때 제1프리코더(422)과 제2프리코더(424)는 각각 자신의 제1프리코딩 행렬과 제2프리코딩 행렬에 의해 데이터 심볼들을 프리코딩할 수 있다.

<58> 기지국(420)의 안테나 어레이(428)는 다수의 안테나들을 사용할 수 있다. 이때 안테나 어레이(428)은 편파 안테나 어레이를 형성할 수도 있다. 무선통신시스템에서 한정된 공간에 보다 많은 안테나들을 배열하기 위해 서로 다른 편파를 가지는 두 개의 안테나들을 교차하여 설치한 이중 편파 안테나 어레이(dual polarized antenna array)를 사용하여 어레이를 구현할 수도 있다. 이때 안테나 어레이들(411, 428)이 이중 편파 안테나 어레이를 사용하는 것을 예시적으로 설명하였으나 이에 제한되지 않는다.

<59> 도 5를 참조하면, 기지국(420)은 수직방향을 기준으로 45도로 편파된 하나의 안테나(428aa 내지 428ad)와 -45도로 편파된 다른 안테나들(428ba 내지 428bd)가 서로 직교하는 안테나쌍 네개를 포함하는 편파 안테나 어레이(428)를 포함하고 있

다. 이때 +45도로 편파된 안테나들(428aa 내지 428ad)을 수신측 제1서브세트 또는 제1도메인(428a)이라 하고 -45도로 편파된 다른 안테나들(428ba 내지 428bd)을 수신측 제2서브세트 또는 제2도메인이라고 할 수 있다.

<60> 단말(10)과 기지국(20) 각각의 편파 안테나들 사이에 위상 불일치(phase mismatch)가 없는 경우 전체 채널 H는 수학식 1과 같이 표현할 수 있다.

<61> [수학식 1]

<62>
$$H = \begin{bmatrix} H_h & 0 \\ 0 & H_v \end{bmatrix}$$

<63> 이때 H_h는 단말(410)의 제1서브세트 또는 제1도메인(410a)과 기지국(420)의 제1서브세트 또는 제1도메인(422a) 사이의 채널을 의미하고 H_v는 제2서브세트 또는 제2도메인(411b)과 기지국(420)의 제2서브세트 또는 제2도메인(428b) 사이의 채널을 의미한다.

<64> 수학식 1을 통해 알 수 있는 바와 같이 서로 다른 방향으로 편파된 안테나들은 서로 직교하면서 위상 불일치가 없는 경우 서로 영향을 주지 않는다. 따라서, H_h와 H_v만을 추정하므로 채널을 알 수 있다. 인접하는 편파 안테나들 사이 거리(d)가 신호 파장(λ)에 비해 작으면 안테나 사이 상관성(correlation)이 클 수 있다. 이때 H_h와 H_v는 안테나 간 거리(d)와 단말(410)에 도달하는 신호 전파의 입사각(θ)에 의해 결정될 수 있다.

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<65> 단말(410)과 기지국(420) 각각의 편파 안테나들 사이에 위상 불일치(phase mismatch)가 존재하는 경우, 예를 들어 단말(410)의 안테나 쌍들이 왼쪽으로 ε 만큼 틀어진 경우 각 편파 도메인에서 전송된 신호들이 단말(410)의 두 개의 편파 도메인들에 모두 수신됨으로 도메인 간 위상차에 따라 도메인간 간섭이 발생할 수 있다. 따라서, 채널은 단말(410)과 기지국(420) 각각의 편파 안테나들 사이에 위상 오차 또는 불일치(phase mismatch)의 정도, 즉 ε 에 의하여 영향을 받게 되어 수학식 2와 같이 표현할 수 있다.

<66> [수학식 2]

【0067】

$$H = \begin{bmatrix} H_h \cos\varepsilon & -H_v \sin\varepsilon \\ H_h \sin\varepsilon & H_v \cos\varepsilon \end{bmatrix}$$

<68> 다시 도4를 참조하면, 제2프리코더(424)는 수평방향과 수직방향으로 교차된 안테나 어레이(428)에 의해 형성하는 편파 도메인(polarized domain) 간 위상 오차 또는 불일치(phase mismatch)의 영향을 제거하기 위해 위상차를 보정하며 제1프리코더(422)는 도메인 간 프리코딩을 수행할 수 있다.

<69> 한편, 동일한 위치에 각 두 개의 안테나를 배치하는 방식으로 이중 편파 도메인이 구성됨으로, 각 편파 도메인은 동일한 공간적 채널 특성을 가질 수 있다. 즉, 각 도메인은 동일한 프리코딩 행렬($H_h=H_v=R_0$)을 사용하여 프리코딩되며, 각 편

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파 도메인을 통해 전송된 신호는 위상 및 크기 차이를 가지고 단말(410)에 도달할 수 있다. 이때 제1프리코더(422)와 제2프리코더(424)에서 사용하는 제1프리코딩 행렬과 제2프리코딩 행렬을 수식으로 표현하면 아래 수학식 3과 같을 수 있다.

<70> [수학식 3]

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

<71>

<72> 상기 수학식3에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한 공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 Λ는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

<73> 각 도메인에 수신된 신호의 크기는 제1프리코딩 행렬 W_1의 R_0의 프리코딩 게인에 의해 결정되며, 제2프리코딩 행렬 W_2은 각 도메인에 수신된 신호 간 위상차를 보정한다. 상기 방식으로 동작 시, 제1프리코딩 행렬 W_1을 설정을 위한 제1인덱스(PMI_1) 선정과 제2프리코딩 행렬 W_2을 설정을 위한 제2인덱스(PMI_2)의 선정은 독립적으로 수행될 수 있다.

<74> 수학식 3을 통해 알 수 있는 바와 같이 프리코더(425)는 두 개의 도메인 (편파 도메인 또는 안테나들의 서브세트) 내에서 각각 프리코딩 게인에 의해 결정되는

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R0을 사용하여 프리코딩을 제1프리코딩 행렬과, 도메인간 위상차 보정(co-phaing) 작업을 수행하는 제 2 프리코딩 행렬로 구성된 프리코더이다. 따라서, 두 개의 독립된 도메인 각각은 프리코딩 게인에 의해 결정되는 R_0을 통해 프리코딩되며 그 중 하나의 도메인은 ∧에 의해 위상 보정된 후 전송된다.

<75> 프리코더(425)에서, 제2프리코딩 행렬은 편파 안테나에서 각 편파 도메인간 위상오차에 의한 신호감쇠를 보정하는 프리코딩 행렬이다. 또한, 제2프리코딩 행렬은 편파 도메인 간 위상오차에 의한 신호감쇠를 보상하는 프리코딩 행렬일 수도 있고, 편파 안테나간 자연스럽게 발생하게 되는 위상차이를 보정하기 위한 프리코딩 행렬일 수도 있다. 기지국(420)은 제1프리코더(422)에 사용되는 N개(N은 1 이상의 자연수)의 제1프리코딩 행렬들과 이들을 인덱싱하는 제1인덱스들을 표현하는 제1코드북과 제2 프리코더(424)에 사용되는 M개(M은 1 이상의 자연수)의 제2프리코딩 행렬들과 이들을 인덱싱하는 제2인덱스들을 표현하는 제2코드북을 저장하고 있다.

<76> 표 2와 표 3은 안테나 어레이(428)이 8개의 이중 편파 안테나들(428a, 428b)을 포함하여 총 8개의 레이어들을 동시 전송할 때 랭크당 각각 16개와 4개의 프리코딩 행렬들을 사용하는 제1코드북과 제2코드북의 예들이다.

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<77> 【표 2】

PMI_1 / RI	0	1	2	.....	15
1	b0	b1	b2	.....	b15
2	b16	b17	b18	.....	b31
.....	.....	.....	.....	.....	.....
8	B111	B112	B113	.....	B120

<78> 【표 3】

PMI1 /RI	0	1	2	3
1	c0	c1	c2	c3
2	c4	c5	c6	c7
....	....	....	....	....
8	c28	c29	c30	c31

<79> 기지국(420)은 랭크들과 랭크들 각각에 대한 제1인덱스들 각각과 제2인덱스들 각각의 쌍에 대응하는 인덱스(이하, 제한 인덱스라 함)를 포함하는 제한북을 저장하고 있다. 표 4는 안테나 어레이(428)이 8개의 이중 편파 안테나들(428a, 428b)을 포함하여 총 8개의 레이어들을 동시 전송할 때 랭크당 각각 16개 및 4개의 프리코딩 행렬들을 사용하는 제한북이다.

<80> 【표 4】

(PMI1 PMI2) / RI	(0.0)	(0.1)	(0.2)	(0.3)	(1.0)	(1.1)	-------	(15.1)	(15.2)	(15.3)
1	a0	a 1	a 2	a 3	a4	a5	------	a61	a62	a63
2	a64	a65	a66	a67	a68	a69	------	a125	a126	a127
------	------	------	------	------	------	------	------	------	------	------
8	a448	a448	a448	a448	a448	a448	------	a509	a510	a511

<81> 코드북 제한시 프리코딩 행렬들 각각의 사용여부를 한비트를 이용하여 지정하는 비트맵 형식으로 코드북제한정보를 전송할 경우 랭크들과 랭크들 각각에 대한 제1인덱스들 각각과 제2인덱스들 각각의 쌍에 대해 총 16×4×8=512 비트들을 필요로 할 수 있다.

<82> 그런데 전술한 바와 같이 제1프리코딩 행렬(W_1)을 설정을 위한 제1인덱스(PMI_1) 선정과 제2프리코딩 행렬(W_2)을 설정을 위한 제2인덱스(PMI_2) 선정은 독립적으로 수행될 수 있으므로 각 랭크에 대해 제1프리코더와 제2프리코더별로 프리코딩 행렬들 각각에 대해 독립적으로 코드북을 제한할 수도 있다. 표 5 는 제한북에서 랭크1에 대해 제1인덱스=0(PMI_1=0) 및 제2인덱스=1(PMI_2=1)에 대하여 코드북 제한을 결정되었을 경우 제한되는 프리코더들을 표현하고 있다.

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<83> 【표 5】

(PMI1, PMI2) / RI	(0,0)	(0,1)	(0,2)	(0,3)	(1,0)	(1,1)	---	(15,1)	(15,2)	(15,3)
1	a0	a1	a2	a3	a4	a5	---	a61	a62	a63
2	a64	a65	a66	a67	a68	a69	---	a125	a126	a127
-----	-----	-----	-----	-----	-----	-----	---	------	------	------
8	a448	a448	a448	a448	a448	a448	---	a509	a510	a511

<84> 표 5에 도시하지 않았지만 8개의 랭크들에 대해서 전술한 랭크1에 대해 코드북 제한하는 방식으로 제1프리코딩 행렬과 제2프리코딩 행렬을 독립적으로 코드북 제한할 수 있다.

<85> 기지국(420)은 각 셀(cell) 단위 또는 사용자(User Equipment) 단위로 사용할/사용하지 않을 프리코딩 행렬을 결정하고 사용하지 않을 프리코딩 행렬에 대한 코드북제한정보를 단말(410)에 전송할 수 있다. 이때 코드북제한정보는 제1 및 제2코드북들에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 포함하고 있다.

<86> 표 5 과 같이 랭크1에 대해 제1인덱스=0(PMI_1=0) 및 제2인덱스=1(PMI_2=1)에 대하여 코드북 제한이 결정되었을 경우 코드북제한정보는 비트맵형식으로 제1정보인 [0111111111111111]와 제2정보인 [1011]를 포함할 수 있다. 전술한 바와 같이 사용할 수 있는 프리코딩 행렬에 대해선 해당 순서에 1로 표시하고 사용하지 않을

프리코딩 행렬에 대해선 해당 순서에 0으로 표시할 수 있다. 결과적으로 제1인덱스=0(PMI_1=0)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.1), (0.1), (0.2), (0.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=1(PMI_2=1)과 쌍을 이루는 제1인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.1), (1.1),….. (14.1), (15.1)도 전체적으로 코드북이 제한된다.

<87> 랭크2에 대해 제1인덱스=1(PMI_1=1) 및 제2인덱스=2(PMI_2=2)에 대하여 코드북 제한이 결정되었을 경우 코드북제한정보는 비트맵형식으로 제1정보인 [1011111111111111]와 제2정보인 [1101]를 포함할 수 있다. 결과적으로 제1인덱스=1(PMI_1=1)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (1.1), (1.1), (1.2), (1.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=2(PMI_2=2)과 쌍을 이루는 제1인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.2), (1.2),….. (14.2), (15.2)도 전체적으로 코드북이 제한된다.

<88> 랭크8에 대해 제1인덱스=0(PMI_1=0) 및 제2인덱스=3(PMI_2=3)에 대하여 코드북 제한이 결정되었을 경우 코드북제한정보는 비트맵형식으로 제1정보인 [0111111111111111]와 제2정보인 [1110]를 포함할 수 있다. 제1인덱스=0(PMI_1=0)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.1), (0.1), (0.2), (0.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=3(PMI_2=3)과 쌍을 이루

는 제1인덱스들, 예를 들어 표 5에서 $(PMI_1\ PMI_2)$= (0.3), (1.3),….. (14.3), (15.3)도 전체적으로 코드북이 제한된다.

<89> 다시 말해, 코드북제한정보는 제1정보와 상기 제2정보를 포함하므로, 제1정보에 따라 제1프리코딩 행렬로 사용되는 것을 제한됨에 따라 사용이 제한된 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고 제2정보에 따라 제2프리코딩 행렬로 사용되는 것을 제한함에 따라 사용이 제한되는 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용을 제한할 수 있다.

<90> 랭크 3 내지 7에 대해서도 동일한 방식으로 코드북제한정보를 비트맵형식으로 제1정보와 제2정보를 포함할 수 있다. 이때 제1정보와 제2정보를 포함하는 코드북제한정보가 비트맵형식인 것으로 설명하였으나 이는 예시에 불과하며 이에 제한되지 않는다.

<91> 전술한 방법과 동일한 방식으로 랭크 1 내지 8도 동일한 비트맵형식으로 코드북제한정보를 전송하면 총 랭크 8에 대한 제1프리코딩 행렬과 제2프리코딩 행렬을 독립적으로 제한하는 코드북제한정보의 총 비트수는 (16+4)×8=160 비트들이 된다.

<92> 기지국(420)은 각 랭크에 대해 20비트씩 비트맵형식으로 랭크 1부터 랭크 8까지 총 160비트로 코드북제한을 표현한 코드북제한정보를 단말(410)에 전송할 수 있다. 이 코드북제한정보는 하향링크 제어정보, 예를 들어 RRC 신호로 물리적 하향링크 공유채널(Physical Downlink Shared Channel, PDSCH)을 통해 기지국(420)으

로부터 단말(410)에 전송될 수 있다. 이때 코드북제한정보는 PDSCH 이외에 물리적 하향링크 제어채널(Physical Downlink Control Channel, PDCCH)과 같은 다른 채널을 통해 기지국(420)으로부터 단말(410)로 전송될 수도 있다. 이때 코드북제한정보는 제1정보와 제2정보를 각 랭크에 대해 순차적으로 포함할 수도 있다. 예를 들어 코드북제한정보는 랭크 1에 대한 제1정보와 제2정보, 랭크 2에 대한 제1정보와 제2정보,…랭크8에 대한 제1정보와 제2정보의 순서로 제1정보와 제2정보를 포함할 수 있다.

<93> 한편, 코드북제한정보는 각 랭크에 대한 제1정보를 순차적으로 포함하고 그 후 각 랭크에 대한 제2정보를 순차적으로 포함할 수도 있다. 예를 들어, 코드북제한정보는 랭크1 내지 랭크 8에 대한 제1정보들을 순차적으로 포함하고, 그후 랭크1 내지 랭크8에 대한 제2정보들을 순차적으로 포함할 수 있다. 물론, 코드북제한정보는 각 랭크별로 제1정보와 제2정보를 독립적으로 기지국(420)으로부터 단말(410)으로 전송될 수도 있다. 물론, 특정 랭크에 대해 코드북을 제한하지 않는 경우 그 특정 코드북에 대한 코드북제한정보는 포함되지 않게 된다.

<94> 결과적으로 제1인덱스와 제2인덱스를 쌍으로 제한할 경우 코드북제한정보가 총 512비트가 필요한 것에 비하여 제1인덱스와 제2인덱스를 독립적으로 결정 및 전송할 경우 코드북제한정보의 피드백 오버헤드를 상당히 줄일 수 있다.

<95> 한편, 제1프리코더(422)가 제1프리코딩 행렬을 사용하여 도메인 간 프리코딩(Intra-domain precoding)시, 예를 들어 제1인덱스=7(PMI_1=7)으로 표기되는 프리코

딩 행렬들이 도메인 간 프리코딩 게인이 적어 사용하지 않는 것으로 코드북을 제한하는 경우, 제2프리코더(424)가 제2프리코딩 행렬을 사용하여 위상차 보정시 PMI_1=7으로 표기되는 어떤 프리코딩 행렬도 우수한 프리코딩 게인을 얻을 수 없다.

<96> 즉, 도메인 간 프리코딩(Intra-domain precoding)을 수행하는 제1프리코딩 행렬에 대한 제한을 결정하는 것이 위상차 보정을 수행하는 제2프리코딩 행렬에 대한 제한을 결정보다 우선할 수도 있다. 따라서, 코드북제한시 제1프리코딩 행렬에 대해서만 제한을 설정할 수도 있다. 이때 코드북제한정보는 제1프리코딩 행렬만을 제한하는 제1정보만을 포함하므로 총 16×8=128비트들이 필요할 수 있다.

<97> 한편, 도메인 간 간섭이 동일한 조건에서 도메인 간 위상차 간섭이 우선할 경우 제2프리코딩 행렬에 대해서만 제한을 설정할 수도 있다. 이때 코드북제한정보는 제2프리코딩 행렬만을 제한하는 제2정보만을 포함하므로 4×8=32비트들이 필요할 수 있다.

<98> 전술한 바와 같이 제1프리코딩 행렬과 제2프리코딩 행렬을 모두 제한하되 독립적으로 제한하는 경우와, 제1프리코딩 행렬만을 제한하는 경우, 제2프리코딩 행렬만을 제한하는 경우를 선택적으로 사용할 수도 있다. 이때는 기지국(420)은 단말(410)에 제한 모드(restriction mode)를 지시하는 총 2비트의 식별표지(restriction mode indicator)를 전송할 수 있다.

<99> 한편, 단말(410)의 채널정보 피드백장치(414)는 코드북제한정보에 포함된 제1정보에 따라 제1프리코딩 행렬로 사용되는 것이 제한된 프리코딩 행렬들을 제외하

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고 제1프리코딩 행렬을 결정하고 그 제1프리코딩 행렬에 대한 제1채널상태정보를 기지국(420)에 보고/피드백할 수 있다. 전술한 예에서 랭크1에 대해 제1인덱스 =0(PMI_1=0)에 대하여 코드북을 제한하는 비트맵형식의 제1정보인 [0111111111111111]를 수신한 경우, 채널정보 피드백장치(414)는 표 5와 같이 제1 인덱스=0(PMI_1=0)를 제외한 인덱스들, 즉 제1인덱스=0에 해당하는 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 제1프리코딩 행렬을 결정하고 그에 대한 제1채널상태정보를 기지국에 보고/피드백할 수 있다. 또한, 각 단말(410)은 코드북제한정보에 포함된 제2정보에 따라 제2프리코딩 행렬로 사용되는 것이 제한된 프리코딩 행렬들을 제외하고 제2프리코딩 행렬을 결정하고 그 제2프리코딩 행렬에 대한 제2채널상태정보를 기지국(420)에 보고/피드백할 수 있다. 전술한 예에서 랭크1에 대해 제2인덱스=1(PMI_2=1)에 대하여 코드북을 제한하는 비트맵형식의 제2정보인 [1011]를 수신한 경우, 채널정보 피드백장치(414)는 표 5와 같이 제2인덱스=1(PMI_2=1)를 제외한 인덱스들, 즉 제2인덱스=1에 해당하는 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 제2프리코딩 행렬을 결정하고 그에 대한 제2채널상태정보를 기지국에 보고/피드백할 수 있다.

<100> 랭크2에 대해 제1인덱스=1(PMI_1=1) 및 제2인덱스=2(PMI_2=2)에 대하여 코드북을 제한하는 비트맵형식의 제1정보인 [1011111111111111]와 제2정보인 [1101]를 수신한 경우 채널정보 피드백장치(414)는 표 5와 같이 랭크2에 대해 제1인덱스

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=1(PMI_1=1) 및 제2인덱스=2(PMI_2=2)를 제외한 제1프리코딩 행렬과 제2프리코딩 행렬을 결정하고 그에 대한 제1채널상태정보와 제2채널상태정보를 기지국에 보고/피드백할 수 있다. 랭크 3 내지 랭크 8도 동일한 방식으로 채널정보 피드백장치(414)는 제1정보와 제2정보에서 지정한 프리코딩 행렬들을 제외하고 제1프리코딩 행렬과 제2프리코딩 행렬을 결정할 수 있다.

<101> 전술한 바와 같이 제1프리코딩 행렬과 제2프리코딩 행렬을 모두 제한하되 독립적으로 제한하는 경우와, 제1프리코딩 행렬만을 제한하는 경우, 제2프리코딩 행렬만을 제한하는 경우를 선택적으로 사용하고 기지국(420)은 단말(410)에 제한 모드를 지시하는 총 2비트의 식별표지(restriction mode indicator)를 전송할 경우 단말(410)의 채널정보 피드백장치(414)는 그 제한 모드에 맞추어 제1프리코딩 행렬과 제2프리코딩 행렬을 결정하고 제1채널상태정보와 제2채널상태정보를 생성 및 보고할 수 있다.

<102> 제1채널상태정보와 제2채널상태정보의 피드백 주기 또는 간격이 다를 수 있다. 예를 들어 제1채널상태정보는 숏텀으로 기지국(420)에 피드백되고 제2채널정보는 롱텀으로 기지국(420)에 피드백될 수 있다. 다시 말해, 긴 주기/롱텀과 짧은 주기/숏텀은 서로 상대적인 의미로, 긴 주기/롱텀은 짧은 주기/숏텀보다 긴 주기를 의미한다.

<103> 기지국(420)의 제1프리코더(422)과 제2프리코더(424)는 각 단말(410)로부터 보고받은 채널상태정보들을 기초로/이용하여 제1및 제2 프리코딩 행렬들을 결정하

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고 그 프리코딩 행렬들을 이용하여 데이터심볼들을 프리코딩한다.

<104> 이상, 또다른 실시예에 따라 코드북제한정보와 채널생태정보를 송수신하는 MIMO 무선통신신스템에 대해 기재하였으나, 이하 또다른 실시예에 따른 송신장치의 통신방법에 대해 기재한다.

<105> 도 6은 또다른 실시예에 따른 송신장치의 통신방법의 흐름도이다.

<106> 도 6을 참조하면, 또다른 실시예에 따른 송신장치의 통신방법(600)는 코드워드를 레이어에 맵핑하는 레이어 맵핑 단계(S610)과 심볼들을 프리코딩하는 프리코딩 단계(S620), 둘 이상의 안테나들을 통해 프리코딩된 심볼을 공중으로 전파하는 전송단계(S630)을 포함할 수 있다. 레이어 맵핑 단계(S610)와 프리코딩 단계(S620), 전송단계(S630)는 전술한 바와 동일하므로 구체적인 설명을 생략한다.

<107> 또다른 실시예에 따른 기지국의 통신방법(600)은 표 5를 참조하여 각 랭크에 대해 표 3의 제1프리코딩 행렬과 표 4의 제2프리코딩 행렬을 독립적으로 코드북 제한하여 각 랭크에 대해 20비트씩 비트맵형식으로 랭크 1부터 랭크 8까지 총 160비트로 코드북제한을 표현한 코드북제한정보를 단말(410)에 전송할 수 있다. 이 코드북제한정보는 하향링크 제어정보, 예를 들어 RRC 신호로 물리적 하향링크 공유채널(Physical Downlink Shared Channel, PDSCH)을 통해 기지국(420)으로부터 단말(410)에 전송될 수 있다. 이때 코드북제한정보는 PDSCH 이외에 물리적 하향링크 제어채널(Physical Downlink Control Channel, PDCCH)과 같은 다른 채널을 통해 기지국(420)으로부터 단말(410)로 전송될 수도 있다.

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<108> 레이어 맵핑 단계(S610)에서 코드북제한정보는 하향링크 제어신호로 레이어에 맵핑될 수 있다.

<109> 기지국(420)은 각 셀(cell) 단위 또는 사용자(User Equipment) 단위로 사용할/사용하지 않을 프리코딩 행렬을 결정하고 사용하지 않을 프리코딩 행렬에 대한 코드북제한정보를 단말(410)에 전송할 수 있다. 이때 코드북제한정보는 제1 및 제2코드북들에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 포함하고 있다.

<110> 표 5 과 같이 랭크1에 대해 제1인덱스=0(PMI_1=0) 및 제2인덱스=1(PMI_2=1)에 대하여 코드북 제한을 결정되었을 경우 코드북제한정보는 비트맵형식으로 제1정보인 [0111111111111111]와 제2정보인 [1011]를 포함할 수 있다.

<111> 프리코딩 단계(S620)에서 레이어에 매핑된 데이터심볼을 자신의 코드북에서 선택한 제1프리코딩 행렬과 제2프리코딩 행렬을 이용하여 프리코딩할 수 있다. 이때 프리코딩 단계(S620)에서 단말과 같은 수신장치로부터 수신받은 제1인덱스와 제2인덱스에 대응하는 제1프리코딩 행렬과 제2프리코딩 행렬을 각각 이용하여 데이터심볼들을 프리코딩할 수 있다. 이때 수신장치로부터 수신받는 제1인덱스와 제2인덱스는 표 3의 제1코드북과 표 4의 제2코드북에서 코드북제한정보에 의해 제한된 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 선정된 프리코딩 행렬들에 대한 인덱스들이다.

<112> 전술한 바와 같이 기지국과 같은 송신장치는 도 5를 참조하여 설명한 바와

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같이 하나의 방향으로 편파된 적어도 하나의 안테나와 다른 방향으로 편파된 적어도 하나의 다른 안테나가 서로 교차하는 적어도 하나의 안테나쌍을 포함할 수 있다.

<113> 이때 수학식 3을 참조하여 설명한 바와 같이 제1프리코딩 행렬은 서로 교차하는 하나의 안테나와 다른 안테나 사이 프리코딩을 수행하는 프리코딩 행렬이며, 제2프리코딩 행렬은 하나의 안테나와 상기 다른 안테나의 위상차 보정을 수행하는 프리코딩 행렬일 수 있다.

<114> 이상, 또다른 실시예에 따른 송신장치의 통신방법에 대해 기재하였으나, 이하 또다른 실시예에 따른 수신장치의 통신방법에 대해 기재한다.

<115> 도 7은 또다른 실시예에 따른 수신장치의 통신방법의 흐름도이다.

<116> 또다른 실시예에 따른 수신장치의 통신방법(700)은 코드북제한정보를 송신장치로부터 수신하는 코드북제한정보 수신단계(S710)과 제1채널상태정보와 제2채널상태정보를 송신장치에 전송하는 채널정보 전송단계(S720)을 포함한다.

<117> 코드북제한정보 수신단계(S710)에서, 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 코드북제한정보로 각각 수신할 수 있다.이때 코드북제한정보는 제1 및 제2 코드북들에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 포함하고 있다.채널정보 전송단계(S720)에서 코드북제한정보를 이용하여 코드북에서 제1프리코딩 행렬

또는 상기 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송할 수 있다.

<118> S710단계와 S720단계를 자세히 설명하면, 전술한 예에서 S710단계에서 수신장치가 랭크1에 대해 제1인덱스=0(PMI_1=0)에 대하여 코드북을 제한하는 비트맵형식의 제1정보인 [0111111111111111]와 제2정보인 [1011]를 수신한 경우, S720단계에서 수신장치는 표 5와 같이 제1인덱스=0(PMI_1=0)를 제외한 인덱스들, 즉 제1인덱스=0에 해당하는 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 제1프리코딩 행렬을 결정하고 그에 대한 제1채널상태정보를 기지국에 보고/피드백하고 제2인덱스=1(PMI_2=1)를 제외한 인덱스들, 즉 제2인덱스=1에 해당하는 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 제2프리코딩 행렬을 결정하고 그에 대한 제2채널상태정보를 기지국에 보고/피드백할 수 있다.

<119> 결과적으로 제1인덱스=0(PMI_1=0)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.1), (0.1), (0.2), (0.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=1(PMI_2=1)과 쌍을 이루는 제1인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.1), (1.1)… (14.1), (15.1)도 전체적으로 코드북이 제한된다.

<120> S710단계에서 수신장치가 랭크2에 대해 제1인덱스=1(PMI_1=1) 및 제2인덱스

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=2(PMI_2=2)에 대하여 코드북을 제한하는 비트맵형식의 제1정보인 [1011111111111111]와 제2정보인 [1101]를 수신한 경우 S720단계에서 수신장치는 표 5와 같이 랭크2에 대해 제1인덱스=1(PMI_1=1) 및 제2인덱스=2(PMI_2=2)를 제외한 제1프리코딩 행렬과 제2프리코딩 행렬을 결정하고 그에 대한 제1채널상태정보와 제2채널상태정보를 기지국에 보고/피드백할 수 있다.

<121> 결과적으로 제1인덱스=1(PMI_1=1)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (1.1), (1.1), (1.2), (1.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=2(PMI_2=2)과 쌍을 이루는 제1인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.2), (1.2)…(14.2), (15.2)도 전체적으로 코드북이 제한된다.

<122> 다시 말해, 코드북제한정보는 제1정보와 상기 제2정보를 포함하므로, 제1정보에 따라 제1프리코딩 행렬로 사용되는 것을 제한됨에 따라 사용이 제한된 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고 제2정보에 따라 제2프리코딩 행렬로 사용되는 것을 제한함에 따라 사용이 제한되는 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용을 제한할 수 있다.

<123> 랭크 3 내지 랭크 8도 동일한 방식으로 수신장치는 제1정보와 제2정보에서 지정한 프리코딩 행렬들을 제외하고 제1프리코딩 행렬과 제2프리코딩 행렬을 결정할 수 있다.

<124> 이상, 실시예들을 통해 다단 구조의 프리코더를 사용할 경우 코드북제한시

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코드북제한정보 또는 채널상태정보를 무선통신시스템에서 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 과정, 코드북제한정보와 채널생태정보를 송수신하는 MIMO 무선통신시스템, 이 무선통신시스템에서 송신장치와 수신장치의 송수신방법 또는 통신방법에 대해 상세히 기재하였다.

<125> 실시예들에 따라 다단 구조의 프리코더들 각각에 대해 프리코딩 행렬들을 제한하는 정보들을 결정하고 그 결정한 정보들을 포함하는 코드북제한정보를 전송하므로 코드북제한정보의 전송 오버헤드를 줄일 수 있다. 실시예들에 따라 무선통신시스템에서 코드북제한기법을 사용하므로 셀 간 간섭을 제어할 수 있다.

<126> 전술한 수식학 3을 통해 설명한 바와 같이 프리코딩 행렬의 정의에 따를 때 각 도메인 또는 안테나의 서브세트내에서의 프리코딩 게인은 제1프리코딩 행렬에 의해 결정된다. 즉, 전체 프리코딩 게인은 제1프리코딩 행렬에 대한 이득과 도메인 또는 서스세트간 위상차 보정(co-phasing) 작업을 수행하는 제2프리코더 행렬의 코딩 이득에 의해 결정될 수 있다. 이때 제2프리코딩 행렬은 도메인 또는 서스세트간 위상차 보정(co-phasing) 작업을 수행하는 프리코딩 행렬이므로 각 단말이 획득할 수 있는 최대 프리코딩 게인은 제1프리코딩 행렬에 의해 결정된다. 다시 말해 각 단말이 수신하는 신호의 전력 또는 수신 가능한 최대 전력은 제1프리코더 또는 제1프리코딩 행렬에 의해 결정되며, 제2프리코더 또는 제2프리코딩 행렬은 각 도메인 또는 안테나 서스세트에 수신된 신호가 위상 보정 작업을 수행할 뿐이다. 다중 접속에 의한 간섭은 제1프리코더 또는 제1프리코딩 행렬에 의해 크게 좌우된다.

<127> 도 8 내지 도 10은 실시예들에 따라 무선통신시스템에서 코드북제한기법을 사용하여 셀 간 간섭을 제어하는 개념도들이다.

<128> 도 8을 참조하면, 빔 포밍시 셀 경계 사용자 단말들(810a 내지 810d)은 셀 간 간섭이 발생할 수 있다. 예를 들어 왜냐하면 810a 및 810b로 표시된 단말들은 도 8에 도시한 바와 같이 제1기지국과 제2기지국의 커버리지 내에 존재하기 때문에 제1기지국 또는 제1셀(820a)의 PMI_1=4 또는 PMI_1=6에 대한 제1프리코딩 행렬로 프리코딩한 신호 전송시 제2기지국 또는 제2셀(820b)의 PMI_1=13에 대한 제2프리코딩 행렬로 프리코딩한 신호 전송은 간섭을 일으킬 수 있다.

<129> 다시 말해 810a 및 810b로 표시된 단말들은 제1기지국 또는 제1셀(820a)의 PMI_1=4 또는 PMI_1=6에 대한 제1프리코딩 행렬로 프리코딩한 전송 신호와 제2기지국 또는 제2셀(820b)의 PMI_1=13에 대한 제2프리코딩 행렬로 프리코딩한 전송 신호를 모두 수신하므로 간섭을 일으킬 수 있다.

<130> 반대로 왜냐하면 810c 및 810d로 표시된 단말들은 도 8에 도시한 바와 같이 제1기지국과 제2기지국의 커버리지 내에 존재하기 때문에 제1기지국(820a)의 PMI_1=8에 대한 제1프리코딩 행렬로 프리코딩한 신호 전송과 제2기지국(820b)의 PMI_1=2 또는 PMI_1=11에 대한 제1프리코딩 행렬로 프리코딩한 신호전송과 간섭을 일으킬 수 있다.

<131> 구체적으로 하나의 단말(810b)을 예를 들어 설명하면, 하나의 단말(810b)은

도 8에 도시한 바와같이 제1기지국(820a) 또는제2기지국(820b) 모두로부터 신호를 수신할 수 있다. 제1기지국(820a)은 하나의 단말(810b)에 신호를 전송하기 위하여 PMI_1=6에 해당하는 제1프리코딩 행렬을 사용하여 신호를 전송하며, 제2기지국(820b)은 하나의 단말(810b)에 신호를 전송하기 위하여 PMI_1=13에 해당하는 제1프리코더 행렬을 사용한다. 결과적으로 도 8에 도시한 바와 같이 하나의 단말(810b)에 제1기지국(820b)이 PMI_1=13을 사용하여 신호를 전송할 때 다른 단말(810a)은 하나의 단말(810b)에게 전송된 신호에 의해 다중 접속 간섭을 받게 된다.

<132> 제2기지국(820b)이 PMI_1=13에 해당하는 제1프리코더 행렬을 사용하지 않도록 코드북 제한을 할 경우, 단말(810b)은 제1기지국(820a)로부터 신호만을 수신받게 되므로 다중 간섭에 의한 셀 간 간섭을 사전에 방지할 수 있다.

<133> 또다른 단말들(810c, 810d)도 위에서 설명한 단말들(810a, 810b)와 동일한 셀간간섭에 의한 다중 접속간섭을 받게 된다.

<134> 제1기지국(820a)이 PMI_1=8에 해당하는 제1프리코더 행렬을 사용하지 않도록 코드북 제한을 할 경우, 단말들(810c, 810d)은 제2기지국(820b)로부터 신호만을 수신받게 되므로 다중 간섭에 의한 셀 간 간섭을 사전에 방지할 수 있다.

<135> 도 9은 전술한 방식으로 코드북 제한을 함으로 셀간 간섭을 발생시킬 것이라예 상되는 제1프리코딩 행렬 또는 이에 대한 인덱스에 대하여 제한을 한 후 이에 근거하여 하향링크 MIMO을 수행한 것을 개념적으로 도시하고 있다.

<136> 도 9을 참조하면, 각 기지국들(820a, 820b)이 PMI_1=13과 PMI_1=8 또는이들에 대응하는 제1프리코딩 행렬의 사용을 제한하는 PMI_1 기반코드북 제한을 수행할 경우, 도 9에 도시한 바와 같이 셀간간섭 발생을 피하거나 줄일 수 있다. 따라서, PMI_2에 대해서는 코드북 제한을 가하지 않고 PMI_1에만 코드북 제한을 가할 경우 전술한 셀간 간섭 제거 효과를 얻을 수 있다.

<137> 도 10을 참조하면, 810b로 표시한 단말은 제1기지국의 PMI_1=6과 제2기지국의 PMI_1=13에 대한 제1프리코딩 행렬로 프리코딩된 신호들을 수신하므로 간섭이 발생하고, 810c로 표시한 단말은 제1기지국의 PMI_1=8과 제2기지국의 PMI_1=2에 대한 제1프리코딩 행렬로 프리코딩된 신호들을 수신하므로 간섭이 발생할 수 있다. 이 경우 제1기지국은 PMI_1=6의 사용을 허가하고 PMI_1=2의 사용을 제한하고 반대로 제2기지국은 PMI_1=2의 사용을 허가하고 PMI_1=6의 사용을 제한하므로 단말들의 간섭을 제거할 수 있다.

<138> 다른 방식으로 이 경우 제1기지국은 PMI_1=8의 사용을 허가하고 PMI_1=13의 사용을 제한하고 반대로 제2기지국은 PMI_1=13의 사용을 허가하고 PMI_1=8의 사용을 제한하므로 단말들의 간섭을 제거할 수 있다.

<139> 다른 방식으로 제1기지국은 PMI_1=6과 PMI_1=8의 사용을 허가하고 제2기지국은

PMI_1=6과 PMI_1=8의 사용을 제한할 수도 있고, 반대로 제1기지국은 PMI_1=6과 PMI_1=8의 사용을 제한하고 제2기지국은 PMI_1=6과 PMI_1=8의 사용을 허가하므로 단말들의 간섭을 제거할 수 있다.

<140> 이와 같이 각 기지국들(820a, 820b)이 PMI_1 기반 코드북 제한을 수행할 경우, 셀간 간섭 발생을 피하거나 줄일 수 있다. PMI_2에 대해서는 코드북 제한을 가하지 않고 PMI_1에만 코드북 제한을 가할 경우 전술한 셀간 간섭 제거 효과를 얻을 수 있다.

<141> 또한 PMI_2에 대해서만 코드북 제한을 가할 경우, 적은 비트수로 코드북을 제한할 수 있는 장점이 있으며, 프리코딩 게인을 직접적으로 제어하는 PMI_1에 제약을 걸지 않아 보다 정밀한 프리코딩이 가능하면서도 코드북 크기를 줄일 수 있다는 장점이 있다.

<142> 이상 도면을 참조하여 실시예들을 상세히 설명하였으나 본 발명은 이에 제한되지 않는다.

<143> 이상과 같은 실시예들은 상향/하향링크 MIMO 시스템에 적용될 수 있으며, 단일 셀(single cell) 환경뿐 아니라 다중 포인트 협력형 송수신 시스템(Coordinated multi-point transmission/reception System; CoMP) 및 이종 네트웍(heterogeneous network) 등 모든 상향/하향링크 MIMO 시스템에 적용될 수 있을 것이다.

<144> 이상에서, 본 발명의 실시예를 구성하는 모든 구성 요소들이 하나로 결합되

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거나 결합되어 동작하는 것으로 설명되었다고 해서, 본 발명이 반드시 이러한 실시예에 한정되는 것은 아니다. 즉, 본 발명의 목적 범위 안에서라면, 그 모든 구성요소들이 하나 이상으로 선택적으로 결합하여 동작할 수도 있다. 또한, 그 모든 구성 요소들이 각각 하나의 독립적인 하드웨어로 구현될 수 있지만, 각 구성 요소들의 그 일부 또는 전부가 선택적으로 조합되어 하나 또는 복수 개의 하드웨어에서 조합된 일부 또는 전부의 기능을 수행하는 프로그램 모듈을 갖는 컴퓨터 프로그램으로서 구현될 수도 있다. 그 컴퓨터 프로그램을 구성하는 코드들 및 코드 세그먼트들은 본 발명의 기술 분야의 당업자에 의해 용이하게 추론될 수 있을 것이다. 이러한 컴퓨터 프로그램은 컴퓨터가 읽을 수 있는 저장매체(Computer Readable Media)에 저장되어 컴퓨터에 의하여 읽혀지고 실행됨으로써, 본 발명의 실시예를 구현할 수 있다. 컴퓨터 프로그램의 저장매체로서는 자기 기록매체, 광 기록매체, 캐리어 웨이브 매체 등이 포함될 수 있다.

<145> 또한, 이상에서 기재된 "포함하다", "구성하다" 또는 "가지다" 등의 용어는, 특별히 반대되는 기재가 없는 한, 해당 구성 요소가 내재될 수 있음을 의미하는 것이므로, 다른 구성 요소를 제외하는 것이 아니라 다른 구성 요소를 더 포함할 수 있는 것으로 해석되어야 한다. 기술적이거나 과학적인 용어를 포함한 모든 용어들은, 다르게 정의되지 않는 한, 본 발명이 속하는 기술 분야에서 통상의 지식을 가진 자에 의해 일반적으로 이해되는 것과 동일한 의미를 가진다. 사전에 정의된 용어와 같이 일반적으로 사용되는 용어들은 관련 기술의 문맥 상의 의미와 일치하는 것으로 해석되어야 하며, 본 발명에서 명백하게 정의하지 않는 한, 이상적이거나

과도하게 형식적인 의미로 해석되지 않는다.

<146> 이상의 설명은 본 발명의 기술 사상을 예시적으로 설명한 것에 불과한 것으로서, 본 발명이 속하는 기술 분야에서 통상의 지식을 가진 자라면 본 발명의 본질적인 특성에서 벗어나지 않는 범위에서 다양한 수정 및 변형이 가능할 것이다. 따라서, 본 발명에 개시된 실시예들은 본 발명의 기술 사상을 한정하기 위한 것이 아니라 설명하기 위한 것이고, 이러한 실시예에 의하여 본 발명의 기술 사상의 범위가 한정되는 것은 아니다. 본 발명의 보호 범위는 아래의 청구범위에 의하여 해석되어야 하며, 그와 동등한 범위 내에 있는 모든 기술 사상은 본 발명의 권리범위에 포함되는 것으로 해석되어야 할 것이다.

【특허청구범위】

【청구항 1】

제1프리코더와 제2프리코더를 포함하는 송신장치에서,

상기 자신의 코드북에서 각 레이어에 대해 상기 제1프리코더의 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코더의 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 각각 결정하는 단계 및

결정한 상기 제1정보와 상기 제2정보 중 적어도 하나를 포함하는 코드북제한정보를 수신장치에 전송하는 단계를 포함하는 송신장치의 통신방법.

【청구항 2】

제1항에 있어서,

상기 수신장치로부터 상기 수신장치가 상기 코드북제한정보를 이용하여 선택한 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 수신하는 단계 및

수신한 상기 제1채널상태정보에 대응하는 제1프리코딩 행렬과 상기 제2채널상태정보에 대응하는 제2프리코딩 행렬을 이용하여 상기 제1프리코더와 상기 제2프리코더로 데이터 심볼들을 프리코딩하여 전송하는 단계를 추가로 포함하는 송신장치의 통신방법.

【청구항 3】

제1항에 있어서,

상기 제1정보와 상기 제2정보는 비트맵형식인 것을 특징으로 하는 송신장치의 통신방법.

【청구항 4】

제3항에 있어서,

상기 코드북제한정보는 상기 제1정보와 상기 제2정보를 포함하므로, 상기 제1정보에 따라 상기 제1프리코딩 행렬로 사용되는 것을 제한됨에 따라 사용이 제한된 상기 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고 상기 제2정보에 따라 상기 제2프리코딩 행렬로 사용되는 것을 제한함에 따라 사용이 제한되는 상기 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용을 제한하는 것을 특징으로 하는 송신장치의 통신방법.

【청구항 5】

제2항에 있어서,

상기 송신장치는 하나의 방향으로 편파된 적어도 하나의 안테나를 포함하는 제1도메인과 다른 방향으로 편파된 적어도 하나의 다른 안테나를 포함하는 제2도메인이 서로 교차하는 적어도 하나의 안테나쌍을 포함하며,

상기 제1프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 별로 각각 프리코딩을 수행하는 프리코딩 행렬이며, 상기 제2프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 간 위상불일치의 영향을 제거하기 위한 위상차 보정을 수행하는 프리코딩 행렬인 것을 특징으로 하는 송신장치의 통신방법.

【청구항 6】

제5항에 있어서,

상기 제1프리코딩 행렬은 아래 수학식의 W1에 해당하며 상기 제2프리코 행렬은 아래 수학식의 W2에 해당하는 것을 특징으로 하는 송신장치의 통신방법.

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

상기 수학식에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한 공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 Λ는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

【청구항 7】

제5항에 있어서,

상기 안테나쌍의 개수는 4개인 것을 특징으로 하는 송신장치의 통신방법.

【청구항 8】

제1항에 있어서,

상기 제1채널상태정보와 상기 제2채널상태정보를 수신하는 단계에서, 상기 제1채널상태정보를 수신하는 주기와 상기 제2채널상태정보를 수신하는 주기가 다른 것을 특징으로 하는 송신장치의 통신방법.

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【청구항 9】

제8항에 있어서,

상기 제1채널상태정보를 수신하는 주기가 상기 제2채널상태정보를 수신하는 주기보다 긴 것을 특징으로 하는 송신장치의 통신방법.

【청구항 10】

제1항에 있어서,

상기 송신장치는 기지국인 것을 특징으로 하는 송신장치의 통신방법.

【청구항 11】

코드워드를 레이어에 매핑하는 레이어 맵퍼

상기 코드워드가 상기 레이어 맵퍼에 의해 상기 레이어에 매핑된 데이터심볼을 자신의 코드북에서 선택한 제1프리코딩 행렬과 제2프리코딩 행렬을 이용하여 프리코딩하는 제1프리코더와 제2프리코더를 포함하는 프리코더

프리코더로부터 출력된 신호들을 전송하는 안테나 어레이를 포함하며,

상기 코드워드는, 상기 코드북에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하는 송신장치.

【청구항 12】

제10항에 있어서,

상기 안테나 어레이는 상기 코드북제한정보를 이용하여 상기 수신장치 자신

의 코드북에서 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 수신하고,

상기 제1프리코더와 상기 제2프리코더 각각은 수신한 상기 제1채널상태정보에 대응하는 제1프리코딩 행렬과 상기 제2채널상태정보에 대응하는 제2프리코딩 행렬을 이용하여 상기 제1프리코더와 상기 제2프리코더로 각각 이용하여 상기 데이터 심볼들을 프리코딩하는 것을 특징으로 하는 송신장치.

【청구항 13】

제11항에 있어서,

상기 제1정보와 상기 제2정보는 비트맵형식인 것을 특징으로 하는 송신장치.

【청구항 14】

제13항에 있어서,

상기 코드북제한정보는 상기 제1정보와 상기 제2정보를 포함하므로, 상기 제1정보에 따라 상기 제1프리코딩 행렬로 사용되는 것을 제한됨에 따라 사용이 제한된 상기 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고 상기 제2정보에 따라 상기 제2프리코딩 행렬로 사용되는 것을 제한함에 따라 사용이 제한되는 상기 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용을 제한하는 것을 특징으로 하는 송신장치.

【청구항 15】

제12항에 있어서,

상기 안테나 어레이는 하나의 방향으로 편파된 적어도 하나의 안테나를 포함하는 제1도메인과 다른 방향으로 편파된 적어도 하나의 다른 안테나를 포함하는 제2도메인이 서로 교차하는 적어도 하나의 안테나쌍을 포함하며,

상기 제1프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 별로 각각 프리코딩을 수행하는 프리코딩 행렬이며, 상기 제2프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 간 위상불일치의 영향을 제거하기 위한 위상차 보정을 수행하는 프리코딩 행렬인 것을 특징으로 하는 송신장치.

【청구항 16】

제15항에 있어서,

상기 제1프리코딩 행렬은 아래 수학식의 W1에 해당하며 상기 제2프리코 행렬은 아래 수학식의 W2에 해당하는 것을 특징으로 하는 송신장치의 통신방법.

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

상기 수학식에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한 공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 Λ는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

【청구항 17】

제15항에 있어서,

상기 제1도메인과 상기 제2도메인은 서로 직교하는 것을 특징으로 하는 송신장치.

【청구항 18】

제15항에 있어서,

상기 안테나쌍의 개수는 4개인 것을 특징으로 하는 송신장치.

【청구항 19】

제11항에 있어서,

상기 송신장치는 기지국인 것을 특징으로 하는 송신장치.

【청구항 20】

무선통신시스템에서,

각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하는 코드북제한정보로 각각 수신하는 수신단계 및

상기 코드북제한정보를 이용하여 상기 코드북에서 상기 제1프리코딩 행렬 또는 상기 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송하는 전송단계를 포함하는 수신장치의 통신

방법.

【청구항 21】

제19항에 있어서,

상기 제1정보와 상기 제2정보는 비트맵형식인 것을 특징으로 하는 수신장치의 통신방법.

【청구항 22】

제19항에 있어서,

상기 코드북제한정보는 상기 제1정보와 상기 제2정보를 포함하므로, 상기 제1정보에 따라 상기 제1프리코딩 행렬로 사용되는 것을 제한됨에 따라 사용이 제한된 상기 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고 상기 제2정보에 따라 상기 제2프리코딩 행렬로 사용되는 것을 제한함에 따라 사용이 제한되는 상기 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용을 제한하는 것을 특징으로 하는 수신장치의 통신방법.

【청구항 23】

제19항에 있어서,

상기 송신장치는 하나의 방향으로 편파된 적어도 하나의 안테나를 포함하는 제1도메인과 다른 방향으로 편파된 적어도 하나의 다른 안테나를 포함하는 제2도메인이 서로 교차하는 적어도 하나의 안테나쌍을 포함하며,

상기 제1프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 별로 각각 프리

코딩을 수행하는 프리코딩 행렬이며, 상기 제2프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 간 위상불일치의 영향을 제거하기 위한 위상차 보정을 수행하는 프리코딩 행렬인 것을 특징으로 하는 수신장치의 통신방법.

【청구항 24】

제23항에 있어서,

상기 제1프리코딩 행렬은 아래 수학식의 W1에 해당하며 상기 제2프리코 행렬은 아래 수학식의 W2에 해당하는 것을 특징으로 하는 송신장치의 통신방법.

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

상기 수학식에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한 공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 Λ는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

【청구항 25】

제20항에 있어서,

상기 전송단계에서, 상기 제1채널상태정보를 전송하는 주기와 상기 제2채널상태정보를 전송하는 주기가 다른 것을 특징으로 하는 수신장치의 통신방법.

【청구항 26】

제25항에 있어서,

상기 제1채널상태정보를 전송하는 주기가 상기 제2채널상태정보를 전송하는 주기보다 긴 것을 특징으로 하는 수신장치의 통신방법.

【청구항 27】

제20항에 있어서,

상기 송신장치는 기지국이며, 상기 수신장치는 단말인 것을 특징으로 하는 수신장치의 통신방법.

【청구항 28】

무선통신시스템에서,

각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제1정보 중 적어도 하나를 코드북제한정보로 수신하는 안테나 어레이 및

상기 코드북제한정보를 이용하여 상기 코드북에서 상기 제1프리코딩 행렬 또는 상기 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송하는 채널정보 피드백장치를 포함하는 수신장치.

【청구항 29】

제28항에 있어서,

상기 제1정보와 상기 제2정보는 비트맵형식인 것을 특징으로 하는 수신장치.

【청구항 30】

제28항에 있어서,

상기 코드북제한정보는 상기 제1정보와 상기 제2정보를 포함하므로, 상기 제1정보에 따라 상기 제1프리코딩 행렬로 사용되는 것을 제한됨에 따라 사용이 제한된 상기 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고 상기 제2정보에 따라 상기 제2프리코딩 행렬로 사용되는 것을 제한함에 따라 사용이 제한되는 상기 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용을 제한하는 것을 특징으로 하는 수신장치.

【청구항 31】

제28항에 있어서, 상기 송신장치는 하나의 방향으로 편파된 적어도 하나의 안테나를 포함하는제1도메인과 다른 방향으로 편파된 적어도 하나의 다른 안테나를 포함하는 제2도메인이 서로 교차하는 적어도 하나의 안테나쌍을 포함하며,

상기 제1프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 별로 각각 프리코딩을 수행하는 프리코딩 행렬이며, 상기 제2프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 간 위상불일치의 영향을 제거하기 위한 위상차 보정을 수행하는 프리코딩 행렬인 것을 특징으로 하는 수신장치.

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【청구항 32】

제31항에 있어서,

상기 제1프리코딩 행렬은 아래 수학식의 W1에 해당하며 상기 제2프리코 행렬은 아래 수학식의 W2에 해당하는 것을 특징으로 하는 송신장치의 통신방법.

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

상기 수학식에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한 공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 Λ는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

【청구항 33】

제28항에 있어서,

상기 제1채널상태정보를 전송하는 주기와 상기 제2채널상태정보를 전송하는 주기가 다른 것을 특징으로 하는 수신장치.

【청구항 34】

제33항에 있어서,

상기 제1채널상태정보를 전송하는 주기가 상기 제2채널상태정보를 전송하는 주기보다 긴 것을 특징으로 하는 수신장치.

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【청구항 35】

제28항에 있어서,

상기 송신장치는 기지국이며, 상기 수신장치는 단말인 것을 특징으로 하는 수신장치.

【요약서】

【요약】

본 발명의 실시예는 무선통신시스템에 관한 것으로서, 송수신단 모두에서 다중입력 다중출력 안테나(MIMO)를 이용하는 무선통신시스템에 관련된 것이다.

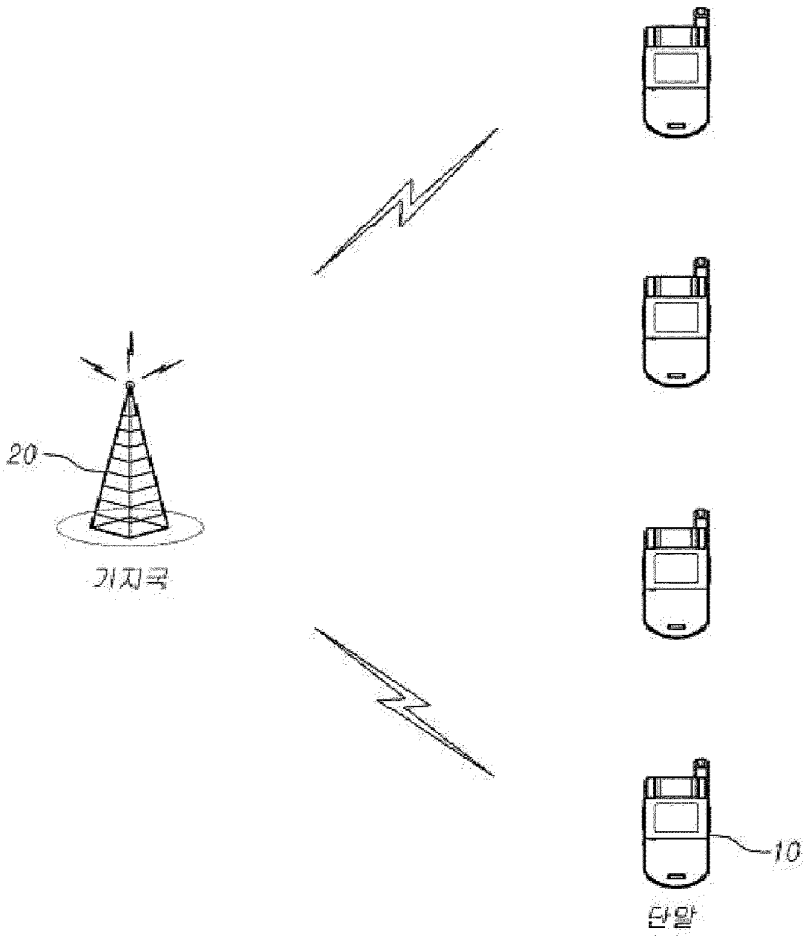
【대표도】

도 3

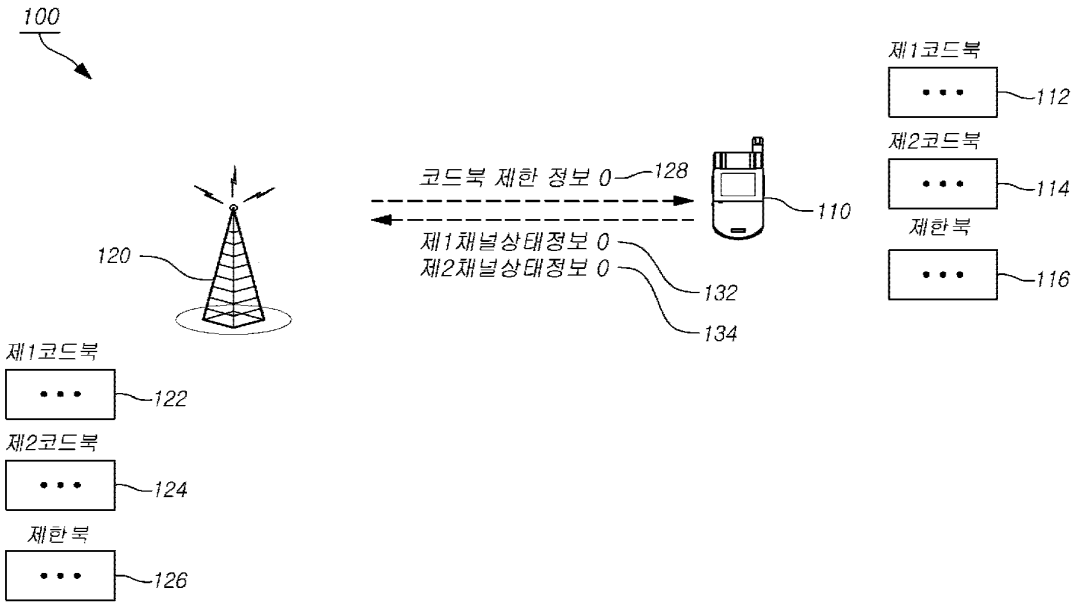
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【도면】

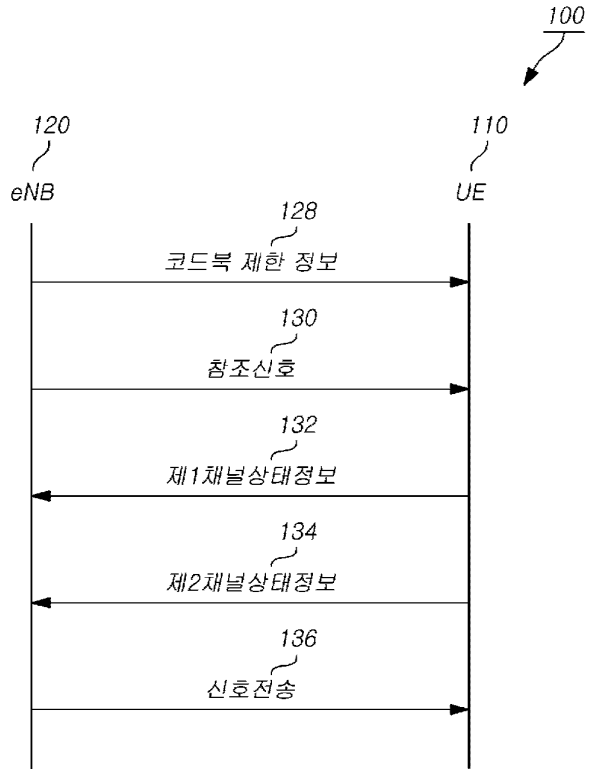
【도 1】



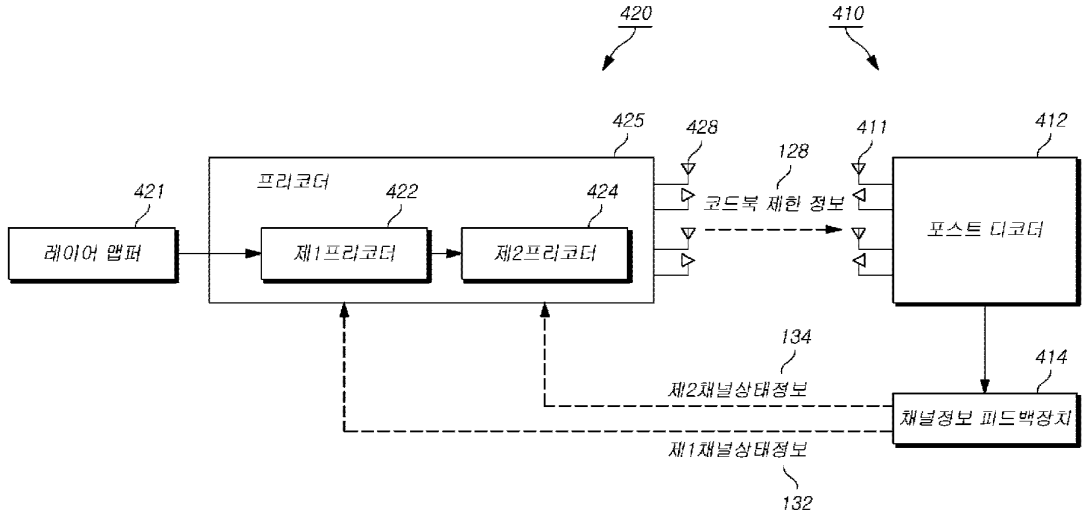
【도 2】


100
제1코드북
112
제2코드북
114
제한북
116
코드북 제한 정보 0
128
110
제1채널상태정보 0
제2채널상태정보 0
132
134
120
제1코드북
122
제2코드북
124
제한북
126

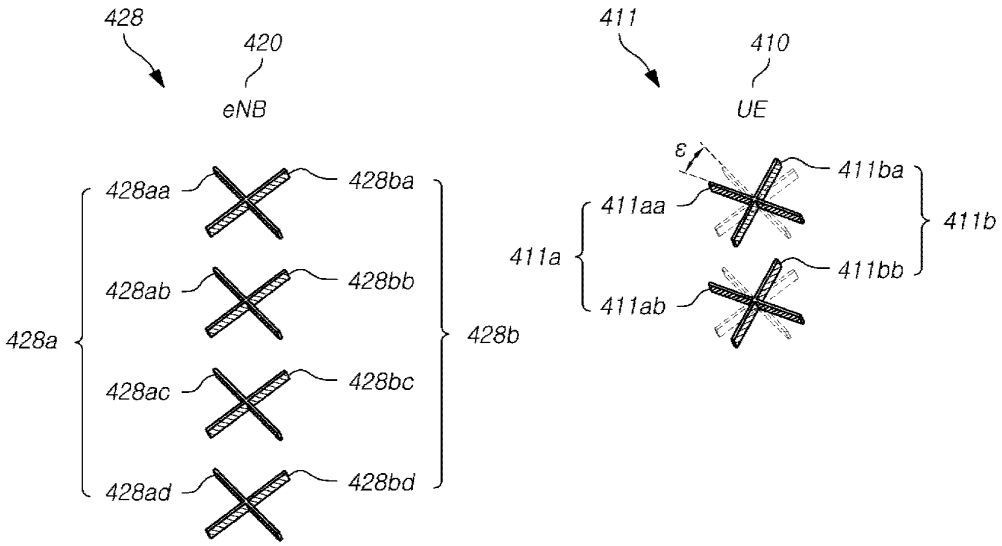
【도 3】


100
120
eNB
110
UE
128
코드북 제한 정보
130
참조신호
132
제1채널상태정보
134
제2채널상태정보
136
신호전송

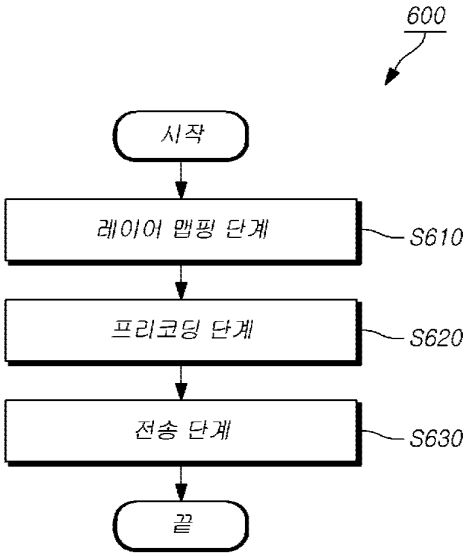
【도 4】


420
410
425
428
411
412
128
421
프리코더
422
424
코드북 제한 정보
레이어 맵퍼
제1프리코더
제2프리코더
포스트 디코더
134
414
제2채널상태정보
채널정보 피드백장치
제1채널상태정보
132

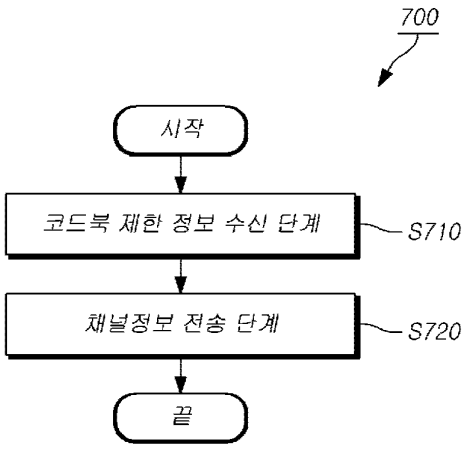
【도 5】


428
420
eNB
411
410
UE
ε
428aa
428ba
428ab
428bb
428ac
428bc
428ad
428bd
428a
428b
411aa
411ba
411b
411a
411ab
411bb

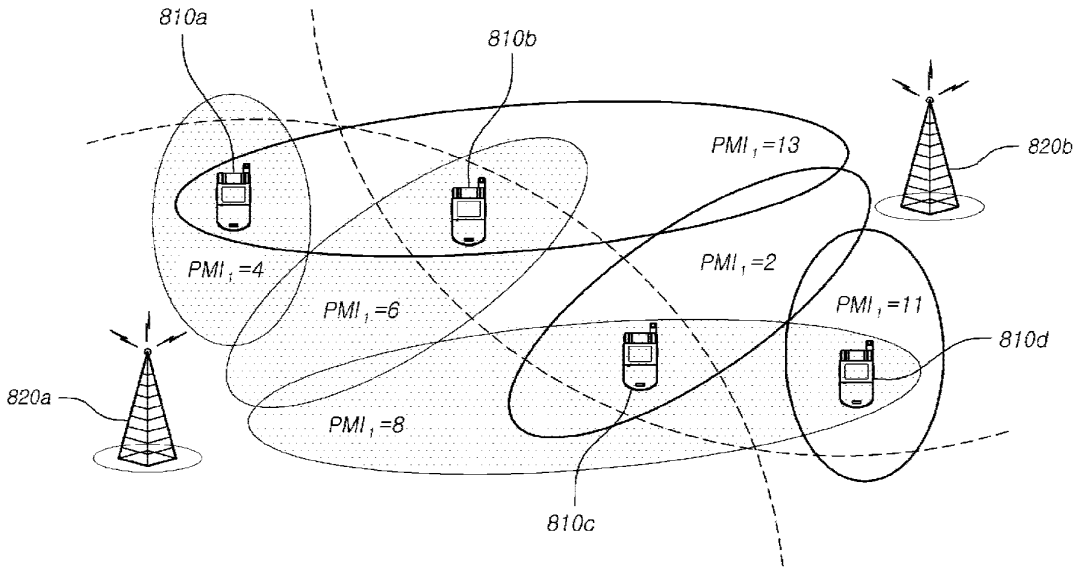
【도 6】


600
시작
레이어 맵핑 단계
S610
프리코딩 단계
S620
전송 단계
S630
끝

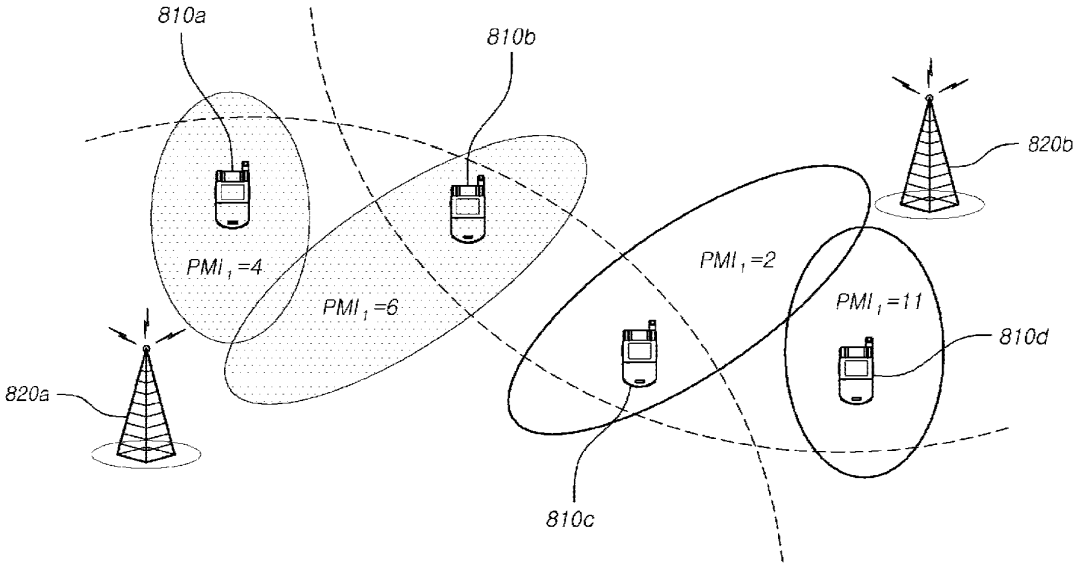
【도 7】


700
시작
코드북 제한 정보 수신 단계
S710
채널정보 전송 단계
S720
끝

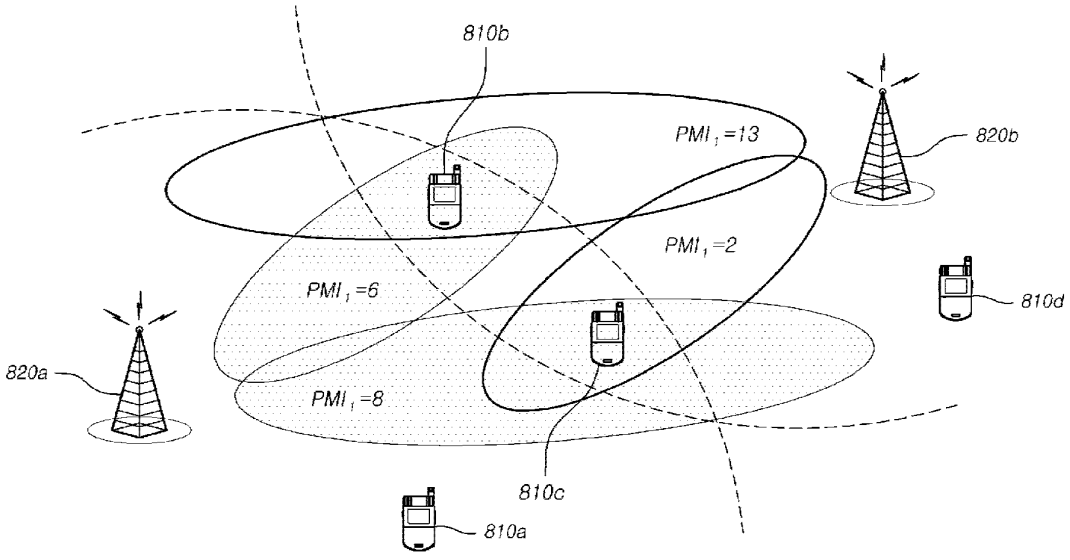
【도 8】


810a
810b
820b
PMI1=13
PMI1=4
PMI1=2
PMI1=11
PMI1=6
810d
820a
PMI1=8
810c

【도 9】


810a
810b
820b
PMI1=4
PMI1=6
PMI1=2
PMI1=11
810d
820a
810c

【도 10】


810b
PMI1=13
820b
PMI1=2
PMI1=6
810d
820a
PMI1=8
810c
810a

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34, chemin des Colombettes
1211 Geneva 20, Switzerland
www.wipo.int

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(72) 발명자; 겸
(75) 발명자/출원인 (US 에 한하여): **박경민 (PARK, Kyoungmin)** [KR/KR]; 서울시 마포구 상암동 DMC, I-2, 팬택빌딩, 121-270 Seoul (KR).

(74) 대리인: **김은구 (KIM, Eungu)** 등; 서울특별시 강남구 역삼동 636-15 상원빌딩 2 층, 135-908 Seoul (KR).

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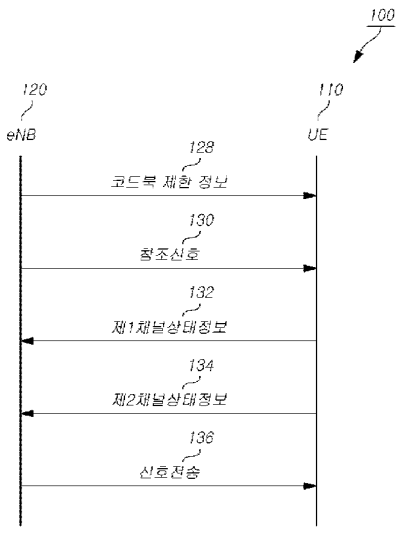
(84) 지정국 (별도의 표시가 없는 한, 가능한 모든 종류의 역내 권리의 보호를 위하여): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), 유라시아 (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), 유럽 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE,

[다음 쪽 계속]

(54) **Title**: TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

(54) **발명의 명칭** : 송신장치 및 그 통신방법, 수신장치, 그 통신방법

[Fig. 3]



120 ... eNB
110 ... UE
128 ... Codebook restriction information
130 ... Reference signal
132 ... 1st Channel status information
134 ... 2nd Channel status information
136 ... Signal transmission

(57) **Abstract**: An embodiment of the present invention relates to a wireless communication system, and more specifically relates to a wireless communication system using multi-input and multi-output (MIMO) antennas in all transmission and reception terminals.

(57) **요약서**: 본 발명의 실시예는 무선통신시스템에 관한 것으로서, 송수신단 모두에서 다중입력 다중출력 안테나(MIMO)를 이용하는 무선통신시스템에 관련된 것이다.

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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, ML, MR, NE, SN, TD, TG).

공개:

— 국제조사보고서 없이 공개하며 보고서 접수 후 이를 별도 공개함 (규칙 48.2(g))

명세서

발명의 명칭: 송신장치 및 그 통신방법, 수신장치, 그 통신방법

기술분야

[1] 본 명세서는 무선통신시스템에 관한 것으로서, 송수신단 모두에서 다중입력 다중출력 안테나(MIMO)를 이용하는 무선통신시스템에 관련된 것이다.

배경기술

[2] 통신 시스템이 발전해나감에 따라 사업체들 및 개인들과 같은 소비자들은 매우 다양한 무선 단말기들을 사용하게 되었다.

[3] 현재의 3GPP, LTE(Long Term Evolution), LTE-A(LTE Advanced)등의 무선통신시스템은 음성 위주의 서비스를 벗어나 영상, 무선 데이터 등의 다양한 데이터를 송수신 할 수 있는 고속 대용량의 통신 시스템으로서, 유선 통신 네트워크에 준하는 대용량 데이터를 전송할 수 있는 기술 개발이 요구되고 있을 뿐 아니라, 정보 손실의 감소를 최소화하고, 시스템 전송 효율을 높임으로써 시스템 성능을 향상시킬 필요가 있었다.

발명의 상세한 설명

과제 해결 수단

[4] 일 실시예는, 제1프리코더와 제2프리코더를 포함하는 송신장치에서, 자신의 코드북에서 각 레이어에 대해 상기 제1프리코더의 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코더의 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 각각 결정하는 단계; 및 결정한 상기 제1정보와 상기 제2정보 중 적어도 하나를 포함하는 코드북제한정보를 수신장치에 전송하는 단계를 포함하는 송신장치의 통신방법을 제공할 수 있다.

[5] 다른 실시예는, 코드워드를 레이어에 매핑하는 레이어 맵퍼; 상기 코드워드가 상기 레이어 맵퍼에 의해 상기 레이어에 매핑된 데이터심볼을 자신의 코드북에서 선택한 제1프리코딩 행렬과 제2프리코딩 행렬을 이용하여 프리코딩하는 제1프리코더와 제2프리코더를 포함하는 프리코더; 프리코더로부터 출력된 신호들을 전송하는 안테나 어레이를 포함하며, 상기 코드워드는, 상기 코드북에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하는 송신장치를 제공할 수 있다.

[6] 다른 실시예는, 무선통신시스템에서, 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하는 코드북제한정보를 수신하는 수신단계; 및 상기 코드북제한정보를 이용하여 코드북에서 상기 제1프리코딩 행렬 또는 상기 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와

제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송하는 전송단계를 포함하는 수신장치의 통신방법을 제공할 수 있다.

[7] 다른 실시예는, 무선통신시스템에서, 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제1정보 중 적어도 하나를 코드북제한정보로 수신하는 안테나 어레이; 및 상기 코드북제한정보를 이용하여 코드북에서 상기 제1프리코딩 행렬 또는 상기 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송하는 채널정보 피드백장치를 포함하는 수신장치를 제공할 수 있다.

도면의 간단한 설명

[8] 도 1은 실시예들이 적용되는 무선 통신 시스템을 개략적으로 나타낸 도면이다.

[9] 도 2는 코드북제한시 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 무선통신시스템을 도시하고 있다.

[10] 도 3은 도 2의 코드북제한정보와 채널상태정보를 교환하는 무선통신시스템에서 참조신호와 신호 전송을 추가로 표시한 흐름도이다.

[11] 도 4는 MIMO 무선통신시스템에서 일실시예에 따른 기지국과 단말 각각의 구성도이다.

[12] 도 5는 도 4의 편파 안테나 어레이를 사용하는 기지국과 단말 사이 채널을 도시하고 있다.

[13] 도 6은 또다른 실시예에 따른 송신장치의 통신방법의 흐름도이다.

[14] 도 7은 또다른 실시예에 따른 수신장치의 통신방법의 흐름도이다.

발명의 실시를 위한 형태

[15] 이하, 본 발명의 일부 실시예들을 예시적인 도면을 통해 상세하게 설명한다. 각 도면의 구성요소들에 참조부호를 부가함에 있어서, 동일한 구성요소들에 대해서는 비록 다른 도면상에 표시되더라도 가능한 한 동일한 부호를 가지도록 하고 있음에 유의해야 한다. 또한, 본 발명을 설명함에 있어, 관련된 공지 구성 또는 기능에 대한 구체적인 설명이 본 발명의 요지를 흐릴 수 있다고 판단되는 경우에는 그 상세한 설명은 생략한다.

[16] 도 1은 실시예들이 적용되는 무선통신시스템을 도시한다.

[17] 무선통신시스템은 음성, 패킷 데이터 등과 같은 다양한 통신 서비스를 제공하기 위해 널리 배치된다.

[18] 도 1을 참조하면, 무선통신시스템은 단말(10; User Equipment, UE) 및 기지국(20; Base Station, BS)을 포함한다.

[19] 본 명세서에서의 단말(10)은 무선 통신에서의 사용자 단말을 의미하는 포괄적 개념으로서, WCDMA 및 LTE, HSPA 등에서의 UE(User Equipment)는 물론, GSM에서의 MS(Mobile Station), UT(User Terminal), SS(Subscriber Station),

무선기기(wireless device) 등을 모두 포함하는 개념으로 해석되어야 할 것이다.

[20] 기지국(20) 또는 셀(cell)은 일반적으로 단말(10)과 통신하는 지점(station)을 말하며, 노드-B(Node-B), eNB(evolved Node-B), BTS(Base Transceiver System), 액세스 포인트(Access Point), 릴레이 노드(Relay Node) 등 다른 용어로 불릴 수 있다

[21] 본 명세서에서 단말(10)과 기지국(20)은 본 명세서에서 기술되는 기술 또는 기술적 사상을 구현하는데 사용되는 두가지 송수신 주체로 포괄적인 의미로 사용되며 특정하게 지칭되는 용어 또는 단어에 의해 한정되지 않는다.

[22] 일실시예는 GSM, WCDMA, HSPA를 거쳐 LTE(Long Term Evolution) 및 LTE-advanced로 진화하는 비동기 무선통신과, CDMA, CDMA-2000 및 UMB로 진화하는 동기식 무선 통신 등에 적용될 수 있다. 본 발명은 특정한 무선통신 분야에 한정되거나 제한되어 해석되어서는 아니되며, 본 발명의 사상이 적용될 수 있는 모든 기술분야를 포함하는 것으로 해석되어야 할 것이다.

[23] 실시예들이 적용되는 무선통신시스템은 상향링크 및/또는 하향링크 HARQ(Hybrid Automatic Repeat request)를 지원할 수 있으며, 링크 적응(link adaptation)을 위해 CQI(channel quality indicator)를 사용할 수 있다. 또한, 하향링크와 상향링크 전송을 위한 다중 접속 방식은 서로 다를 수 있으며, 예컨데, 하향링크는 OFDMA(Orthogonal Frequency Division Multiple Access)를 사용하고, 상향링크는 SC-FDMA(Single Carrier-Frequency Division Multiple Access)를 사용할 수 있다.

[24] 무선통신시스템은 사용자에게 고속 정보 전송을 지원하기 위해서 다중 안테나를 포함하는 안테나 어레이를 사용하여 동일 대역을 통해 정보를 전달하는 다중 입력 다중 출력(Multiple Input Multiple Output, MIMO) 기법의 사용을 고려하고 있다.

[25] 한편, 효과적인 MIMO 시스템 구현을 위해, MIMO 무선통신시스템은 전송 용량 증대를 위해 전파 채널에 대한 정보 또는 전파 채널에 적합한 프리코더 또는 프리코딩 행렬(이하 프리코딩 행렬이라 함)에 대한 정보를 전송장치에 제공하여야 한다. 이때 전자는 큰 피드백 오버헤드를 요구하는 반면, 후자는 상대적으로 적은 피드백 오버헤드를 요구한다.

[26] 후자의 경우 각 단말(10)과 기지국(20)은 사용 가능한 N개의 프리코딩 행렬들을 한정하고 각 프리코딩 행렬을 표시하는 또는 인덱싱하는(에 대응하는) 인덱스 또는 인디케이터, 식별표시를 표현하는 코드북을 저장한다. 각 단말(10)은 전파 채널에 적합한 프리코딩 행렬을 선정하고, 선정한 프리코딩 행렬을 인덱싱하는 인덱스를 기지국(20)에 송신한다, 기지국(20)은 각 단말(10)로부터 프리코딩 행렬 인덱스들을 수신하고, 이들을 이용하여 MIMO 모드나 단말을 선정하거나, 프리코딩을 수행한다.

[27] 이때 사용 가능한 프리코딩 행렬들의 수가 많아 코드북의 크기가 클수록 기지국(120)의 프리코딩 성능은 증가하나 프리코딩 행렬 또는 그 인덱스를

기지국(20)에 보고하기 위한 단말(10)의 피드백 오버헤드는 증가할 수 있다. 따라서, 보다 효과적인 프리코딩을 위해 큰 크기 코드북(large size codebook)을 사용하되 코드북에서 적어도 하나의 프리코딩 행렬을 제한하는 코드북제한(codebook restriction) 또는 코드북 서브세트 제한(codebook subset restriction)을 사용할 수 있다.

[28] 코드북제한(codebook restriction)은 다양한 프리코딩 행렬들을 포함하는 코드북을 생성한 후 코드북에서 각 셀(cell) 단위 또는 사용자(User Equipment) 단위로 사용할/사용하지 않을 프리코딩 행렬을 선정하고 사용하지 않을 프리코딩 행렬에 대한 코드북제한정보(이하, "코드북제한정보"라 함)를 통해 각 셀 단위 또는 사용자 단위로 다른 코드북을 사용하는 기법이다. 이 코드북제한 기법의 사용시 무선통신시스템 전체는 큰 크기의 코드북을 가지지만 각 셀 또는 각 사용자가 사용하는 코드북은 코드북의 서브세트로 구성되어 크기가 작으면서 주어진 환경에 적합한 프리코딩 행렬만으로 구성되어 프리코딩 게인을 증가시킬 수 있다.

[29] 예를 들어 기지국(20)과 단말(10) 사이 하향링크 MIMO 전송시 최대 4개의 레이어들로 동시 전송할 수 있는 경우, 단말(10)은 자신이 수신할 수 있는 레이어의 수를 랭크 지시자(Rank Indicator, RI)를 사용하여 기지국(20)에 전달할 수 있다. 이 경우 기지국(20)과 단말(10) 사이 하향링크 MIMO 전송시 각 랭크당 16개의 프리코딩 행렬들을 지정하여 총 64개의 프리코딩 행렬들로 표 1과 같이 코드북을 구성할 수 있다.

[30] [표 1]

[31]

RI \ PMI	0	1	2	·····	15
1	a0	a1	a2	·····	a15
2	a16	a17	a18	·····	a31
3	a32	a33	a34	·····	a47
4	a48	a49	a50	·····	a63

[32] 코드북 제한시 64개의 프리코딩 행렬들 각각에 대하여 사용 여부를 결정하고 프리코딩 행렬들 각각의 사용여부를 1 비트를 이용하여 지정하는 비트맵 형식으로 코드북제한정보를 전송할 경우 총 64비트가 필요할 수 있다. 예를 들어 [001010010……010]와 같이 사용할 수 있는 프리코딩 행렬에 대해선 해당 순서에 1로 표시하고 사용하지 않을 프리코딩 행렬에 대해선 해당 순서에 0으로 표시할 수 있다.

[33] 한편, 단말(10)은 채널상태정보로 총 64개의 프리코딩 행렬들에 대응하는 64개의 인덱스들을 총 6비트를 사용하여 기지국(20)에 보고할 수 있다. 이때 총 64개의 프리코딩 행렬들 중 32개의 프리코딩 행렬들의 사용을 제한하는

코드북제한시 6비트로 구분해야 하는 정보의 수가 64에서 32로 감소하여 피드백 신호의 신뢰도를 증가시킬 수 있다. 한편, 단말(10)은 프리코딩 행렬들에 대응하는 인덱스들을 표현하는 비트수를 5비트로 줄여 채널상태정보의 피드백 오버헤드를 줄일 수도 있다.

[34] 아울러, 코드북 제한을 사용하여 셀간 간섭(Inter-cell interference)을 발생시킬 것이라 예상되는 프리코딩 행렬들의 사용을 제한하여 셀간 간섭의 발생을 사전에 방지할 수도 있다. 특히 각 단말의 위치에 기반한 빔 형성 기반 프리코딩(beam-forming like precoding)을 수행할 경우, 셀 경계(cell edge)에 위치한 단말은 심각한 셀 간 간섭을 발생시킬 수 있다. 이를 사전에 방지하기 위하여 셀 별 코드북 제한을 수행하여 셀 간 간섭을 제어할 수 있다.

[35] 기지국(20)은 적어도 두개의 프리코더들을 포함하는 다단 구조의 프리코더를 사용할 수 있다. 다단 구조의 프리코더를 사용할 경우도 각 프리코더에 사용하는 프리코딩 행렬을 제한하는 코드북제한을 사용할 수 있다. 이 경우 전체적으로 프리코딩 행렬들의 수가 증가하며 코드북제한을 위해 사용하는 코드북제한정보를 위해 사용되는 비트수도 증가할 수 있다.

[36] 특히, 상향링크 또는 하향링크에서 고속 정보 전송을 지원하기 위해 높은 시그널링과 피드백 오버헤드를 사용해야 하기 때문에, 기지국(20)이 각 단말(10)에코드북 제한을 알리기 위해 사용하는 비트수도 줄일 필요가 있다.

[37] 이상 실시예들이 적용되는 무선통신시스템을 설명하였으나 이하 도 2 및 도3을 참조하여 다단 구조의 프리코더를 사용할 경우 코드북제한시 무선통신시스템에서 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 과정을 기재한다.

[38] 도 2는 코드북제한시 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 무선통신시스템을 도시하고 있다.

[39] 도 2를 참조하면, 무선통신시스템(100)은 도 1의 무선통신시스템과 동일하게 기지국(120)과 무선통신시스템(100) 내에 존재하는 적어도 하나의 단말, 예를 들어 n개의 단말들(110)을 포함할 수 있다. 이 단말들(110)은 현재 접속되어 있거나 추가 접속을 시도하는 단말들일 수 있으나 도 2에는 하나의 단말만을 표시한다.

[40] 기지국(120)은 후술하는 바와 같이 적어도 두개의 제1및 제2프리코더들을 포함하는 다단 구조의 프리코더를 포함하고 있다. 기지국(120)은 제1프리코더에 사용되는 N개의 제1프리코딩 행렬들과 이들을 인덱싱하는 제1인덱스들을 표현하는 제1코드북(122)과 제2 프리코더에 사용되는 M개의 제2프리코딩 행렬들과 이들을 인덱싱하는 제2인덱스들을 표현하는 제2코드북(124)을 저장하고 있다.

[41] 기지국(120)은 랭크들과 랭크들 각각에 대한 제1인덱스들 각각과 제2인덱스들 각각의 쌍에 대응하는 인덱스(이하, 제한 인덱스라 함)를 포함하는 제한북(126, restriction book)을 저장하고 있다. 기지국(120)은 각 셀(cell) 단위 또는

사용자(User Equipment) 단위로 사용할/사용하지 않을 프리코딩 행렬을 결정하고 사용하지 않을 프리코딩 행렬에 대한 코드북제한정보(128)를 단말(110)에 전송할 수 있다. 이때 코드북제한정보(128)는 제1 및 제2코드북들(122, 124)에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 포함하고 있다.

[42] 도 3은 도 2의 코드북제한정보와 채널상태정보를 교환하는 무선통신시스템에서 참조신호와 신호 전송을 추가로 표시한 흐름도이다.

[43] 도 3을 참조하면, 단말(110)과 기지국(120) 사이 데이터를 송수신하기 위해 송신자 측 기지국(120)은 도 3에 추가로 도시한 바와 같이 참조신호(130)를 전송하고, 수신자 측 단말(receiver side, 110)은 이 참조신호(130)를 이용하여 채널을 추정할 수 있다. 예를 들어, 하향링크 전송시 단말(110)은 하향링크 채널을 추정할 수 있다. 특히 OFDM 전송시 단말(110)은 각 서브캐리어의 채널을 추정할 수 있다. 반대로, 상향링크 전송시 기지국(120)은 상향링크 채널을 추정할 수 있다.

[44] 채널의 추정을 위해 주파수-도메인 그리드 내에 규칙 또는 불규칙한 간격으로 특정 신호 또는 심볼을 삽입할 수 있다. 이때 이 특정 신호 또는 심볼을 참조신호(reference signal) 또는 참조심볼(reference symbol), 파일롯 심볼(pilot symbol) 등 다양하게 명명하고 본 명세서에서는 이 특정 신호 또는 심볼을 참조신호라 하나 그 용어에 제한되지 않는다. 물론 참조신호(130)는 주파수 도메인 채널의 추정에만 사용되지 않고 단말과 기지국 사이의 무선통신 과정에서 필요한 위치추정, 제어정보의 송수신, 스케줄링정보의 송수신, 피드백정보의 송수신 등을 위해서 사용될 수도 있다.

[45] 하향링크 또는 상향링크 전송시 각각 여러 종류의 참조신호들이 존재하며 다양한 용도로 새로운 참조신호들이 정의되고 있으며 논의되기도 한다. 예를 들어 상향링크 전송시 참조신호로 DM-RS(Demodulation RS), SRS(Sounding RS) 등이 있다. 하향링크 전송시 참조신호로 DM-RS(Demodulation RS), CRS(Cell-specific RS), MBSFN RS, UE-specific RS 등이 있다. 또한, 하향링크 전송시 단말(110)에서 중심 셀 또는 인접 셀들의 채널상태정보(Channel State Information(CSI))를 획득하기 위하여 기지국에서 전송하는 참조신호로 CSI-RS가 있다. 이 CSI-RS는 CQI(Channel Quality Indicator)/PMI(Precoder Matrix Indicator)/RI(Rank Indicator) 등을 리포팅하는데 사용될 수 있다. 이 CSI-RS는 CSI-RS를 전송하는 기지국에 포함된 각 셀마다 서로 구분가능하도록 셀-특화(Cell-specific)되며 낮은 오버헤드를 위해 주파수와 시간에서 충분히 산재해야 한다.

[46] 다시 도 2를 참조하면, 단말(110)은 제1프리코더에 사용되는 N개의 제1프리코딩 행렬들과 이들을 인덱싱하는 제1인덱스들을 표현하는 제1코드북(112)과 제2 프리코더에 사용되는 M개의 제2프리코딩 행렬들과 이들을 인덱싱하는 제2인덱스들을 표현하는 제2코드북(114)을 저장하고 있다.

제1코드북(112)와 제2코드북(114)는 각각 기지국(120)가 저장하고 있는 제1코드북(122)와 제2코드북(124)와 동일하다.

[47] 단말(110)은 랭크들과 랭크들 각각에 속하는 제1인덱스 및 제2인덱스 쌍에 대응한 복수의 인덱스들(이하, 제한 인덱스라 함)을 포함하는, 표 4를 참조하여 후술할, 제한북(116)을 저장하고 있다. 각 단말(110)이 저장하고 있는 제한북(116)은 기지국(120)이 저장하고 있는 제한북(126)과 동일하다.

[48] 단말(110)은 기지국(120)으로부터 전술한 코드북제한정보(128)를 수신할 수 있다. 이 코드북제한정보(128)는 제1 및 제2코드북들에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하고 있다.

[49] 단말(110)은 코드북제한정보(128)에 포함된 제1정보에 따라 제1프리코딩 행렬로 사용되는 것이 제한된 프리코딩 행렬들을 제외하고 제1프리코딩 행렬을 결정하고 그 제1프리코딩 행렬에 대한 제1채널상태정보(132)를 기지국(120)에 보고/피드백할 수 있다. 또한, 각 단말(110)은 코드북제한정보(128)에 포함된 제2정보에 따라 제2프리코딩 행렬로 사용되는 것이 제한된 프리코딩 행렬들을 제외하고 제2프리코딩 행렬을 결정하고 그 제2프리코딩 행렬에 대한 제2채널상태정보(134)를 기지국(120)에 보고/피드백할 수 있다.

[50] 기지국(120)은 각 단말(110)로부터 보고받은 채널상태정보들(132, 134)을 기초로 이용하여 제1코드북(122)와 제2코드북(124)에서 제1프리코더와 제2프리코더의 프리코딩 행렬들을 결정하고 그 프리코딩 행렬들을 이용하여 데이터심볼들을 프리코딩한다.

[51] 다시 도 3을 참조하면, 최종적으로 기지국(120)은 도 3에 추가로 도시한 바와 같이 프리코딩된 신호(136)를 단말(110)에 전송한다. 반대로 단말(110)은 이 신호(136)을 수신한 후 원 데이터를 디코딩한다.

[52] 이상 다단 구조의 프리코더를 사용할 경우 코드북제한시 무선통신시스템에서 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 과정을 설명하였으나 이하에서 코드북제한정보와 채널생태정보를 송수신하는 MIMO 무선통신시스템에 대해 상세히 기재한다.

[53] 도 4는 MIMO 무선통신시스템에서 일실시예에 따른 기지국과 단말 각각의 구성도이다. 도 5는 도 4의 편파 안테나 어레이를 사용하는 기지국과 단말 사이 채널을 도시하고 있다.

[54] 도 4을 참조하면, MIMO 무선통신시스템은 단말(410)과 기지국(420)을 포함할 수 있다.

[55] 단말(410)은 하향링크 채널을 통해 신호를 수신하는 안테나 어레이(411)와 수신한 신호를 처리하고 프리코딩 행렬을 이용하여 원래의 데이터 심볼로 디코딩하는 포스트 디코더(post-decoder, 412), 채널정보 피드백장치(414)를 포함한다.

[56] 안테나 어레이(411)는 다수의 안테나들을 사용할 수 있다. 이때 안테나

어레이(411)은 편파 안테나 어레이를 형성할 수도 있다. 무선통신시스템에서 한정된 공간에 보다 많은 안테나들을 배열하기 위해 서로 다른 편파를 가지는 두 개의 안테나들을 교차하여 설치한 이중 편파 안테나 어레이(dual polarized antenna array)를 사용하여 어레이를 구현할 수도 있다.

[57] 도 5를 참조하면, 수직방향을 기준으로 오른쪽으로 편파된 것으로 "+"로 표시하고 왼쪽으로 편파된 것을 "-"로 표시할 때 단말(410)은 수직방향을 기준으로 45도로 편파된 하나의 안테나들(411aa 내지 411ab)와 -45도로 편파된 다른 안테나(411ba 내지 411bb)가 서로 직교하는 안테나쌍 두개를 포함하는 편파 안테나 어레이(411)를 포함하고 있다. 이때 +45도로 편파된 안테나들(411aa 내지 411ab)은 송신측 제1서브세트 또는 제1도메인(411a)이라 할 수 있고 -45도로 편파된 다른 안테나들(411ba 내지 411bb)은 송신측 제2서브세트 또는 제2도메인(411b)이라고 할 수 있다.

[58] 다시 도 4를 참조하면, 포스트 디코더(412)는 기지국(420)의 제1프리코더(422)와 제2프리코더(424)에 대응된다. 포스트 디코더(412)는 수신한 참조신호를 채널정보 피드백장치(414)에 전달한다.

[59] 채널정보 피드백장치(414)는 참조신호를 수신하고 이 참조신호를 이용하여 채널을 추정할 수 있다. 채널정보 피드백장치(414)는 제1채널상태정보와 제2채널상태정보를 포함하는 채널정보를 생성할 수 있다. 채널정보 피드백장치(414)는 이 채널정보를 기지국(420)에 피드백할 수 있다.

[60] 기지국(420)은 코드워드를 레이어에 맵핑하는 레이어 맵퍼(421)와 레이어 매핑된 데이터 심볼들을 프리코딩 행렬을 이용하여 프리코딩하는 프리코더(425), 프리코딩된 신호를 공중으로(on air)으로 전송하는 안테나 어레이(428)를 포함한다. 프리코더(425)는 데이터 심볼들을 프리코딩하는 제1프리코더(422)와 제2프리코더(424)를 포함할 수 있다. 이때 제1프리코더(422)과 제2프리코더(424)는 각각 자신의 제1프리코딩 행렬과 제2프리코딩 행렬에 의해 데이터 심볼들을 프리코딩할 수 있다.

[61] 기지국(420)의 안테나 어레이(428)는 다수의 안테나들을 사용할 수 있다. 이때 안테나 어레이(428)은 편파 안테나 어레이를 형성할 수도 있다. 무선통신시스템에서 한정된 공간에 보다 많은 안테나들을 배열하기 위해 서로 다른 편파를 가지는 두 개의 안테나들을 교차하여 설치한 이중 편파 안테나 어레이(dual polarized antenna array)를 사용하여 어레이를 구현할 수도 있다. 이때 안테나 어레이들(411, 428)이 이중 편파 안테나 어레이를 사용하는 것을 예시적으로 설명하였으나 이에 제한되지 않는다.

[62] 도 5를 참조하면, 기지국(420)은 수직방향을 기준으로 45도로 편파된 하나의 안테나(428aa 내지 428ad)와 -45도로 편파된 다른 안테나들(428ba 내지 428bd)가 서로 직교하는 안테나쌍 네개를 포함하는 편파 안테나 어레이(428)를 포함하고 있다. 이때 +45도로 편파된 안테나들(428aa 내지 428ad)을 수신측 제1서브세트 또는 제1도메인(428a)이라 하고 -45도로 편파된 다른 안테나들(428ba 내지

428bd)을 수신측 제2서브세트 또는 제2도메인(428b)이라고 할 수 있다.

[63] 단말(410)과 기지국(420) 각각의 편파 안테나들 사이에 위상 불일치(phase mismatch)가 없는 경우 전체 채널 H는 수학식 1과 같이 표현할 수 있다.

[64] [수학식 1]

[65]

$$H = \begin{bmatrix} H_h & 0 \\ 0 & H_v \end{bmatrix}$$

[66] 이때 H_h는 단말(410)의 제1서브세트 또는 제1도메인(411a)과 기지국(420)의 제1서브세트 또는 제1도메인(428a) 사이의 채널을 의미하고 H_v는 제2서브세트 또는 제2도메인(411b)과 기지국(420)의 제2서브세트 또는 제2도메인(428b) 사이의 채널을 의미한다.

[67] 수학식 1을 통해 알 수 있는 바와 같이 서로 다른 방향으로 편파된 안테나들은 서로 직교하면서 위상 불일치가 없는 경우 서로 영향을 주지 않는다. 따라서, H_h와 H_v만을 추정하므로 채널을 알 수 있다. 인접하는 편파 안테나들 사이 거리(d)가 신호 파장(λ)에 비해 작으면 안테나 사이 상관성(correlation)이 클 수 있다. 이때 H_h와 H_v는 안테나 간 거리(d)와 단말(410)에 도달하는 신호 전파의 입사각(θ)에 의해 결정될 수 있다.

[68] 단말(410)과 기지국(420) 각각의 편파 안테나들 사이에 위상 불일치(phase mismatch)가 존재하는 경우, 예를 들어 단말(410)의 안테나 쌍들이 왼쪽으로 ε 만큼 틀어진 경우 기지국(420)의 각 편파 도메인에서 전송된 신호들이 단말(410)의 두 개의 편파 도메인들에 모두 수신됨으로 도메인 간 위상차에 따라 도메인간 간섭이 발생할 수 있다. 따라서, 채널은 단말(410)과 기지국(420) 각각의 편파 안테나들 사이에 위상 오차 또는 불일치(phase mismatch)의 정도, 즉 ε 에 의하여 영향을 받게 되어 전체 채널 H는 수학식 2와 같이 표현할 수 있다.

[69] [수학식 2]

[70]

$$H = \begin{bmatrix} H_h \cos\varepsilon & -H_v \sin\varepsilon \\ H_h \sin\varepsilon & H_v \cos\varepsilon \end{bmatrix}$$

[71] 다시 도4를 참조하면, 제2프리코더(424)는 수평방향과 수직방향으로 교차된 안테나 어레이(428)에 의해 형성하는 편파 도메인(polarized domain) 간 위상 오차 또는 불일치(phase mismatch)의 영향을 제거하기 위해 위상차를 보정하며 제1프리코더(422)는 도메인 간 프리코딩을 수행할 수 있다.

[72] 한편, 동일한 위치에 각 두 개의 안테나를 배치하는 방식으로 이중 편파 도메인이 구성됨으로, 각 편파 도메인은 동일한 공간적 채널 특성을 가질 수 있다. 즉, 각 도메인은 동일한 프리코딩 행렬($H_h=H_v=R_0$)을 사용하여 프리코딩되며, 각 편파 도메인을 통해 전송된 신호는 위상 및 크기 차이를 가지고 단말(410)에 도달할 수 있다. 이때 제1프리코더(422)와 제2프리코더(424)에서 사용하는 제1프리코딩 행렬과 제2프리코딩 행렬을 수식으로 표현하면 아래 수학식 3과 같을 수 있다.

[73] [수학식 3]

[74]

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

[75] 상기 수학식3에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한 공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 Λ는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

[76] 각 도메인에 수신된 신호의 크기는 제1프리코딩 행렬 W_1의 R_0의 프리코딩 게인에 의해 결정되며, 제2프리코딩 행렬 W_2은 각 도메인에 수신된 신호 간 위상차를 보정한다. 상기 방식으로 동작 시, 제1프리코딩 행렬 W_1을 설정을 위한 제1인덱스(PMI_1) 선정과 제2프리코딩 행렬 W_2을 설정을 위한 제2인덱스(PMI_2)의 선정은 독립적으로 수행될 수 있다.

[77] 수학식 3을 통해 알 수 있는 바와 같이 프리코더(425)는 두 개의 도메인 (편파 도메인 또는 안테나들의 서브세트) 내에서 각각 프리코딩 게인에 의해 결정되는 R_0을 사용하여 프리코딩을 수행하는 제1프리코딩 행렬과, 도메인간 위상차 보정(co-phaing) 작업을 수행하는 제 2 프리코딩 행렬로 구성된 프리코더이다. 따라서, 두 개의 독립된 도메인 각각은 프리코딩 게인에 의해 결정되는 R_0을 통해 프리코딩되며 그 중 하나의 도메인은 Λ에 의해 위상 보정된 후 전송된다.

[78] 프리코더(425)에서, 제2프리코딩 행렬은 편파 안테나에서 각 편파 도메인간위상오차에 의한 신호감쇠를 보정하는 프리코딩 행렬이다. 또한, 제2프리코딩 행렬은 편파 도메인 간 위상오차에 의한 신호감쇠를 보상하는 프리코딩 행렬일 수도 있고, 편파 안테나간 자연스럽게 발생하게 되는 위상차이를 보정하기 위한 프리코딩 행렬일 수도 있다. 기지국(420)은

제1프리코더(422)에 사용되는 N개(N은 1 이상의 자연수)의 제1프리코딩 행렬들과 이들을 인덱싱하는 제1인덱스들을 표현하는 제1코드북과 제2 프리코더(424)에 사용되는 M개(M은 1 이상의 자연수)의 제2프리코딩 행렬들과 이들을 인덱싱하는 제2인덱스들을 표현하는 제2코드북을 저장하고 있다.

[79] 표 2와 표 3은 안테나 어레이(428)이 8개의 이중 편파 안테나들(428a, 428b)을 포함하여 총 8개의 레이어들을 동시 전송할 때 랭크당 각각 16개와 4개의 프리코딩 행렬들을 사용하는 제1코드북과 제2코드북의 예들이다.

[80] [표 2]

[81]

RI \ PMI_1	0	1	2	.....	15
1	b0	b1	b2	.....	b15
2	b16	b17	b18	.....	b31
.....	.....	.....	.....	.....	.....
8	b112	b113	b114	.....	b127

[82] [표 3]

[83]

RI \ PMI_2	0	1	2	3
1	c0	c1	c2	c3
2	c4	c5	c6	c7
.....	.....	.....	.....	.....
8	c28	c29	c30	c31

[84] 기지국(420)은 랭크들과 랭크들 각각에 대한 제1인덱스들 각각과 제2인덱스들 각각의 쌍에 대응하는 인덱스(이하, 제한 인덱스라 함)를 포함하는 제한북을 저장하고 있다. 표 4는 안테나 어레이(428)가 8개의 이중 편파 안테나들(428a, 428b)을 포함하여 총 8개의 레이어들을 동시 전송할 때 랭크당 각각 16개 및 4개의 프리코딩 행렬들을 사용하는 제한북이다.

[85] [표 4]

[86]

RI \ (PMI_1, PMI_2)	(0.0)	(0.1)	(0.2)	(0.3)	(1.0)	(1.1)	.....	(15.1)	(15.2)	(15.3)
1	a0	a 1	a 2	a 3	a4	a5	.....	a61	a62	a63
2	a64	a65	a66	a67	a68	a69	.....	a125	a126	a127
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	a448	a449	a450	a451	a452	a453	.....	a509	a510	a511

[87] 코드북 제한시 프리코딩 행렬들 각각의 사용여부를 한비트를 이용하여 지정하는 비트맵 형식으로 코드북제한정보를 전송할 경우 랭크들과 랭크들 각각에 대한 제1인덱스들 각각과 제2인덱스들 각각의 쌍에 대해 총 $16\times4\times8 = 512$ 비트들을 필요로 할 수 있다.

[88] 그런데 전술한 바와 같이 제1프리코딩 행렬(W_1)을 설정을 위한 제1인덱스(PMI_1) 선정과 제2프리코딩 행렬(W_2)을 설정을 위한 제2인덱스(PMI_2) 선정은 독립적으로 수행될 수 있으므로 각 랭크에 대해 제1프리코더와 제2프리코더별로 프리코딩 행렬들 각각에 대해 독립적으로 코드북을 제한할 수도 있다. 표 5 는 제한북에서 랭크1에 대해 제1인덱스=0(PMI_1=0) 및 제2인덱스=1(PMI_2=1)에 대하여 코드북 제한을 결정되었을 경우 제한되는 프리코더들을 표현하고 있다.

[89] [표 5]

[90]

RI \ (PMI_1, PMI_2)	(0.0)	(0.1)	(0.2)	(0.3)	(1.0)	(1.1)	.....	(15.1)	(15.2)	(15.3)
1	a0	a1	a2	a3	a4	a5	.....	a61	a62	a63
2	a64	a65	a66	a67	a68	a69	.....	a125	a126	a127
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	a448	a449	a450	a451	a452	a453	.....	a509	a510	a511

[91] 표 5에 도시하지 않았지만 8개의 랭크들에 대해서 전술한 랭크1에 대해 코드북 제한하는 방식으로 제1프리코딩 행렬과 제2프리코딩 행렬을 독립적으로 코드북 제한할 수 있다.

[92] 기지국(420)은 각 셀(cell) 단위 또는 사용자(User Equipment) 단위로 사용할/사용하지 않을 프리코딩 행렬을 결정하고 사용하지 않을 프리코딩 행렬에 대한 코드북제한정보를 단말(410)에 전송할 수 있다. 이때 코드북제한정보는 제1 및 제2코드북들에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을

제한하는 제2정보를 포함하고 있다.

[93] 표 5 과 같이 랭크1에 대해 제1인덱스=0(PMI_1=0) 및 제2인덱스=1(PMI_2=1)에 대하여 코드북 제한이 결정되었을 경우 코드북제한정보는 비트맵형식으로 제1정보인 [0111111111111111]와 제2정보인 [1011]를 포함할 수 있다. 전술한 바와 같이 사용할 수 있는 프리코딩 행렬에 대해선 해당 순서에 1로 표시하고 사용하지 않을 프리코딩 행렬에 대해선 해당 순서에 0으로 표시할 수 있다. 결과적으로 제1인덱스=0(PMI_1=0)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (**0**.1), (**0**.1), (**0**.2), (**0**.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=1(PMI_2=1)과 쌍을 이루는 제1인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.1), (1.1),….. (14.1), (15.1)도 전체적으로 코드북이 제한된다.

[94] 랭크2에 대해 제1인덱스=1(PMI_1=1) 및 제2인덱스=2(PMI_2=2)에 대하여 코드북 제한이 결정되었을 경우 코드북제한정보는 비트맵형식으로 제1정보인 [1011111111111111]와 제2정보인 [1101]를 포함할 수 있다. 결과적으로 제1인덱스=1(PMI_1=1)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (**1**.1), (**1**.1), (**1**.2), (**1**.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=2(PMI_2=2)과 쌍을 이루는 제1인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.2), (1.2),….. (14.2), (15.2)도 전체적으로 코드북이 제한된다.

[95] 랭크8에 대해 제1인덱스=0(PMI_1=0) 및 제2인덱스=3(PMI_2=3)에 대하여 코드북 제한이 결정되었을 경우 코드북제한정보는 비트맵형식으로 제1정보인 [0111111111111111]와 제2정보인 [1110]를 포함할 수 있다. 제1인덱스=0(PMI_1=0)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (**0**.1), (**0**.1), (**0**.2), (**0**.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=3(PMI_2=3)과 쌍을 이루는 제1인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.3), (1.3),….. (14.3), (15.3)도 전체적으로 코드북이 제한된다.

[96] 다시 말해, 코드북제한정보는 제1정보와 상기 제2정보를 포함하므로, 제1정보에 따라 제1프리코딩 행렬로 사용되는 것을 제한됨에 따라 사용이 제한된 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고 제2정보에 따라 제2프리코딩 행렬로 사용되는 것을 제한함에 따라 사용이 제한되는 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용을 제한할 수 있다.

[97] 랭크 3 내지 7에 대해서도 동일한 방식으로 코드북제한정보를 비트맵형식으로 제1정보와 제2정보를 포함할 수 있다. 이때 제1정보와 제2정보를 포함하는 코드북제한정보가 비트맵형식인 것으로 설명하였으나 이는 예시에 불과하며 이에 제한되지 않는다.

[98] 전술한 방법과 동일한 방식으로 랭크 1 내지 8도 동일한 비트맵형식으로 코드북제한정보를 전송하면 총 랭크 8에 대한 제1프리코딩 행렬과 제2프리코딩 행렬을 독립적으로 제한하는 코드북제한정보의 총 비트수는 (16 + 4)×8 = 160 비트들이 된다.

[99] 기지국(420)은 각 랭크에 대해 20비트씩 비트맵형식으로 랭크 1부터 랭크 8까지 총 160비트로 코드북제한을 표현한 코드북제한정보를 단말(410)에 전송할 수 있다. 이 코드북제한정보는 하향링크 제어정보, 예를 들어 RRC 신호로 물리적 하향링크 공유채널(Physical Downlink Shared Channel, PDSCH)을 통해 기지국(420)으로부터 단말(410)에 전송될 수 있다. 이때 코드북제한정보는 PDSCH 이외에 물리적 하향링크 제어채널(Physical Downlink Control Channel, PDCCH)과 같은 다른 채널을 통해 기지국(420)으로부터 단말(410)로 전송될 수도 있다. 이때 코드북제한정보는 제1정보와 제2정보를 각 랭크에 대해 순차적으로 포함할 수도 있다. 예를 들어 코드북제한정보는 랭크 1에 대한 제1정보와 제2정보, 랭크 2에 대한 제1정보와 제2정보,...랭크8에 대한 제1정보와 제2정보의 순서로 제1정보와 제2정보를 포함할 수 있다.

[100] 한편, 코드북제한정보는 각 랭크에 대한 제1정보를 순차적으로 포함하고 그후 각 랭크에 대한 제2정보를 순차적으로 포함할 수도 있다. 예를 들어, 코드북제한정보는 랭크1 내지 랭크 8에 대한 제1정보들을 순차적으로 포함하고, 그후 랭크1 내지 랭크8에 대한 제2정보들을 순차적으로 포함할 수 있다. 물론, 코드북제한정보는 각 랭크별로 제1정보와 제2정보를 독립적으로 기지국(420)으로부터 단말(410)으로 전송될 수도 있다. 물론, 특정 랭크에 대해 코드북을 제한하지 않는 경우 그 특정 코드북에 대한 코드북제한정보는 포함되지 않게 된다.

[101] 결과적으로 제1인덱스와 제2인덱스를 쌍으로 제한할 경우 코드북제한정보가 총 512비트가 필요한 것에 비하여 제1인덱스와 제2인덱스를 독립적으로 결정 및 전송할 경우 코드북제한정보의 피드백 오버헤드를 상당히 줄일 수 있다.

[102] 한편, 제1프리코더(422)가 제1프리코딩 행렬을 사용하여 도메인 간 프리코딩(Intra-domain precoding)시, 예를 들어 제1인덱스=7(PMI_1=7)으로 표기되는 프리코딩 행렬들이 도메인 간 프리코딩 게인이 적어 사용되지 않는 것으로 코드북을 제한하는 경우, 제2프리코더(424)가 제2프리코딩 행렬을 사용하여 위상차 보정시 PMI_1=7으로 표기되는 어떤 프리코딩 행렬도 우수한 프리코딩 게인을 얻을 수 없다.

[103] 즉, 도메인 간 프리코딩(Intra-domain precoding)을 수행하는 제1프리코딩 행렬에 대한 제한을 결정하는 것이 위상차 보정을 수행하는 제2프리코딩 행렬에 대한 제한을 결정하는 것보다 우선할 수도 있다. 따라서, 코드북제한시 제1프리코딩 행렬에 대해서만 제한을 설정할 수도 있다. 이때 코드북제한정보는 제1프리코딩 행렬만을 제한하는 제1정보만을 포함하므로 총 $16 \times 8 = 128$ 비트들이 필요할 수 있다.

[104] 한편, 도메인 간 간섭이 동일한 조건에서 도메인 간 위상차 간섭이 우선할 경우 제2프리코딩 행렬에 대해서만 제한을 설정할 수도 있다. 이때 코드북제한정보는 제2프리코딩 행렬만을 제한하는 제2정보만을 포함하므로 $4 \times 8 = 32$ 비트들이 필요할 수 있다.

[105] 전술한 바와 같이 제1프리코딩 행렬과 제2프리코딩 행렬을 모두 제한하되 독립적으로 제한하는 경우와, 제1프리코딩 행렬만을 제한하는 경우, 제2프리코딩 행렬만을 제한하는 경우를 선택적으로 사용할 수도 있다. 이때는 기지국(420)은 단말(410)에 제한 모드(restriction mode)를 지시하는 총 2비트의 식별표지(restriction mode indicator)를 전송할 수 있다.

[106] 한편, 단말(410)의 채널정보 피드백장치(414)는 코드북제한정보에 포함된 제1정보에 따라 제1프리코딩 행렬로 사용되는 것이 제한된 프리코딩 행렬들을 제외하고 제1프리코딩 행렬을 결정하고 그 제1프리코딩 행렬에 대한 제1채널상태정보를 기지국(420)에 보고/피드백할 수 있다. 전술한 예에서 랭크1에 대해 제1인덱스=0(PMI_1=0)에 대하여 코드북을 제한하는 비트맵형식의 제1정보인 [0111111111111111]를 수신한 경우, 채널정보 피드백장치(414)는 표 5와 같이 제1인덱스=0(PMI_1=0)를 제외한 인덱스들, 즉 제1인덱스=0에 해당하는 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 제1프리코딩 행렬을 결정하고 그에 대한 제1채널상태정보를 기지국에 보고/피드백할 수 있다. 또한, 각 단말(410)은 코드북제한정보에 포함된 제2정보에 따라 제2프리코딩 행렬로 사용되는 것이 제한된 프리코딩 행렬들을 제외하고 제2프리코딩 행렬을 결정하고 그 제2프리코딩 행렬에 대한 제2채널상태정보를 기지국(420)에 보고/피드백할 수 있다. 전술한 예에서 랭크1에 대해 제2인덱스=1(PMI_2=1)에 대하여 코드북을 제한하는 비트맵형식의 제2정보인 [1011]를 수신한 경우, 채널정보 피드백장치(414)는 표 5와 같이 제2인덱스=1(PMI_2=1)를 제외한 인덱스들, 즉 제2인덱스=1에 해당하는 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 제2프리코딩 행렬을 결정하고 그에 대한 제2채널상태정보를 기지국에 보고/피드백할 수 있다.

[107] 랭크2에 대해 제1인덱스=1(PMI_1=1) 및 제2인덱스=2(PMI_2=2)에 대하여 코드북을 제한하는 비트맵형식의 제1정보인 [1011111111111111]와 제2정보인 [1101]를 수신한 경우 채널정보 피드백장치(414)는 표 5와 같이 랭크2에 대해 제1인덱스=1(PMI_1=1) 및 제2인덱스=2(PMI_2=2)를 제외한 제1프리코딩 행렬과 제2프리코딩 행렬을 결정하고 그에 대한 제1채널상태정보와 제2채널상태정보를 기지국에 보고/피드백할 수 있다. 랭크 3 내지 랭크 8도 동일한 방식으로 채널정보 피드백장치(414)는 제1정보와 제2정보에서 지정한 프리코딩 행렬들을 제외하고 제1프리코딩 행렬과 제2프리코딩 행렬을 결정할 수 있다.

[108] 전술한 바와 같이 제1프리코딩 행렬과 제2프리코딩 행렬을 모두 제한하되 독립적으로 제한하는 경우와, 제1프리코딩 행렬만을 제한하는 경우, 제2프리코딩 행렬만을 제한하는 경우를 선택적으로 사용하고 기지국(420)은 단말(410)에 제한 모드를 지시하는 총 2비트의 식별표지(restriction mode indicator)를 전송할 경우 단말(410)의 채널정보 피드백장치(414)는 그 제한 모드에 맞추어 제1프리코딩 행렬과 제2프리코딩 행렬을 결정하고

제1채널상태정보와 제2채널상태정보를 생성 및 보고할 수 있다.

[109] 제1채널상태정보와 제2채널상태정보의 피드백 주기 또는 간격이 다를 수 있다. 예를 들어 제1채널상태정보는 숏텀으로 기지국(420)에 피드백되고 제2채널정보는 롱텀으로 기지국(420)에 피드백될 수 있다. 다시 말해, 긴 주기/롱텀과 짧은 주기/숏텀은 서로 상대적인 의미로, 긴 주기/롱텀은 짧은 주기/숏텀보다 긴 주기를 의미한다.

[110] 기지국(420)의 제1프리코더(422)과 제2프리코더(424)는 각 단말(410)로부터 보고받은 채널상태정보들을 기초로/이용하여 제1및 제2 프리코딩 행렬들을 결정하고 그 프리코딩 행렬들을 이용하여 데이터심볼들을 프리코딩한다.

[111] 이상, 또다른 실시예에 따라 코드북제한정보와 채널생태정보를 송수신하는 MIMO 무선통신신스템에 대해 기재하였으나, 이하 또다른 실시예에 따른 송신장치의 통신방법에 대해 기재한다.

[112] 도 6은 또다른 실시예에 따른 송신장치의 통신방법의 흐름도이다.

[113] 도 6을 참조하면, 또다른 실시예에 따른 송신장치의 통신방법(600)는 코드워드를 레이어에 맵핑하는 레이어 맵핑 단계(S610)과 심볼들을 프리코딩하는 프리코딩 단계(S620), 둘 이상의 안테나들을 통해 프리코딩된 심볼을 공중으로 전파하는 전송단계(S630)을 포함할 수 있다. 레이어 맵핑 단계(S610)와 프리코딩 단계(S620), 전송단계(S630)는 전술한 바와 동일하므로 구체적인 설명을 생략한다.

[114] 또다른 실시예에 따른 기지국의 통신방법(600)은 표 5를 참조하여 각 랭크에 대해 표 3의 제1프리코딩 행렬과 표 4의 제2프리코딩 행렬을 독립적으로 코드북 제한하여 각 랭크에 대해 20비트씩 비트맵형식으로 랭크 1부터 랭크 8까지 총 160비트로 코드북제한을 표현한 코드북제한정보를 단말(410)에 전송할 수 있다. 이 코드북제한정보는 하향링크 제어정보, 예를 들어 RRC 신호로 물리적 하향링크 공유채널(Physical Downlink Shared Channel, PDSCH)을 통해 기지국(420)으로부터 단말(410)에 전송될 수 있다. 이때 코드북제한정보는 PDSCH 이외에 물리적 하향링크 제어채널(Physical Downlink Control Channel, PDCCH)과 같은 다른 채널을 통해 기지국(420)으로부터 단말(410)로 전송될 수도 있다.

[115] 레이어 맵핑 단계(S610)에서 코드북제한정보는 하향링크 제어신호로 레이어에 맵핑될 수 있다.

[116] 기지국(420)은 각 셀(cell) 단위 또는 사용자(User Equipment) 단위로 사용할/사용하지 않을 프리코딩 행렬을 결정하고 사용하지 않을 프리코딩 행렬에 대한 코드북제한정보를 단말(410)에 전송할 수 있다. 이때 코드북제한정보는 제1 및 제2코드북들에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 포함하고 있다.

[117] 표 5 과 같이 랭크1에 대해 제1인덱스=0(PMI_1=0) 및 제2인덱스=1(PMI_2=1)에

대하여 코드북 제한을 결정되었을 경우 코드북제한정보는 비트맵형식으로 제1정보인 [0111111111111111]와 제2정보인 [1011]를 포함할 수 있다.

[118] 프리코딩 단계(S620)에서 레이어에 매핑된 데이터심볼을 자신의 코드북에서 선택한 제1프리코딩 행렬과 제2프리코딩 행렬을 이용하여 프리코딩할 수 있다. 이때 프리코딩 단계(S620)에서 단말과 같은 수신장치로부터 수신받은 제1인덱스와 제2인덱스에 대응하는 제1프리코딩 행렬과 제2프리코딩 행렬을 각각 이용하여 데이터 심볼들을 프리코딩할 수 있다. 이때 수신장치로부터 수신받는 제1인덱스와 제2인덱스는 표 3의 제1코드북과 표 4의 제2코드북에서 코드북제한정보에 의해 제한된 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 선정된 프리코딩 행렬들에 대한 인덱스들이다.

[119] 전술한 바와 같이 기지국과 같은 송신장치는 도 5를 참조하여 설명한 바와 같이 하나의 방향으로 편파된 적어도 하나의 안테나와 다른 방향으로 편파된 적어도 하나의 다른 안테나가 서로 교차하는 적어도 하나의 안테나쌍을 포함할 수 있다.

[120] 이때 수학식 3을 참조하여 설명한 바와 같이 제1프리코딩 행렬은 서로 교차하는 하나의 안테나와 다른 안테나 사이 프리코딩을 수행하는 프리코딩 행렬이며, 제2프리코딩 행렬은 하나의 안테나와 상기 다른 안테나의 위상차 보정을 수행하는 프리코딩 행렬일 수 있다.

[121] 이상, 또다른 실시예에 따른 송신장치의 통신방법에 대해 기재하였으나, 이하 또다른 실시예에 따른 수신장치의 통신방법에 대해 기재한다.

[122] 도 7은 또다른 실시예에 따른 수신장치의 통신방법의 흐름도이다.

[123] 또다른 실시예에 따른 수신장치의 통신방법(700)은 코드북제한정보를 송신장치로부터 수신하는 코드북제한정보 수신단계(S710)과 제1채널상태정보와 제2채널상태정보를 송신장치에 전송하는 채널정보 전송단계(S720)을 포함한다.

[124] 코드북제한정보 수신단계(S710)에서, 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 코드북제한정보로 각각 수신할 수 있다.이때 코드북제한정보는 제1 및 제2코드북들에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 포함하고 있다.채널정보 전송단계(S720)에서 코드북제한정보를 이용하여 코드북에서 제1프리코딩 행렬 또는 상기 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송할 수 있다.

[125] S710단계와 S720단계를 자세히 설명하면, 전술한 에에서 S710단계에서 수신장치가 랭크1에 대해 제1인덱스=0(PMI_1=0)에 대하여 코드북을 제한하는 비트맵형식의 제1정보인 [0111111111111111]와 제2정보인 [1011]를 수신한 경우, S720단계에서 수신장치는 표 5와 같이 제1인덱스=0(PMI_1=0)를 제외한

인덱스들, 즉 제1인덱스=0에 해당하는 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 제1프리코딩 행렬을 결정하고 그에 대한 제1채널상태정보를 기지국에 보고/피드백하고 제2인덱스=1(PMI_2=1)를 제외한 인덱스들, 즉 제2인덱스=1에 해당하는 프리코딩 행렬들을 제외한 프리코딩 행렬들 중 제2프리코딩 행렬을 결정하고 그에 대한 제2채널상태정보를 기지국에 보고/피드백할 수 있다.

[126] 결과적으로 제1인덱스=0(PMI_1=0)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (**0**.1), (**0**.1), (**0**.2), (**0**.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=1(PMI_2=1)과 쌍을 이루는 제1인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.1), (1.1)… (14.1), (15.1)도 전체적으로 코드북이 제한된다.

[127] S710단계에서 수신장치가 랭크2에 대해 제1인덱스=1(PMI_1=1) 및 제2인덱스=2(PMI_2=2)에 대하여 코드북을 제한하는 비트맵형식의 제1정보인 [1011111111111111]와 제2정보인 [1101]를 수신한 경우 S720단계에서 수신장치는 표 5와 같이 랭크2에 대해 제1인덱스=1(PMI_1=1) 및 제2인덱스=2(PMI_2=2)를 제외한 제1프리코딩 행렬과 제2프리코딩 행렬을 결정하고 그에 대한 제1채널상태정보와 제2채널상태정보를 기지국에 보고/피드백할 수 있다.

[128] 결과적으로 제1인덱스=1(PMI_1=1)과 쌍을 이루는 제2인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (**1**.1), (**1**.1), (**1**.2), (**1**.3)도 전체적으로 코드북이 제한된다. 반대로 제2인덱스=2(PMI_2=2)과 쌍을 이루는 제1인덱스들, 예를 들어 표 5에서 (PMI_1 PMI_2)= (0.2), (1.2)…(14.2), (15.2)도 전체적으로 코드북이 제한된다.

[129] 다시 말해, 코드북제한정보는 제1정보와 상기 제2정보를 포함하므로, 제1정보에 따라 제1프리코딩 행렬로 사용되는 것을 제한됨에 따라 사용이 제한된 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고 제2정보에 따라 제2프리코딩 행렬로 사용되는 것을 제한함에 따라 사용이 제한되는 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용을 제한할 수 있다.

[130] 랭크 3 내지 랭크 8도 동일한 방식으로 수신장치는 제1정보와 제2정보에서 지정한 프리코딩 행렬들을 제외하고 제1프리코딩 행렬과 제2프리코딩 행렬을 결정할 수 있다.

[131] 이상, 실시예들을 통해 다단 구조의 프리코더를 사용할 경우 코드북제한시 무선통신시스템에서 기지국과 단말이 코드북제한정보와 채널상태정보를 교환하는 과정, 코드북제한정보와 채널생태정보를 송수신하는 MIMO 무선통신시스템, 이 무선통신시스템에서 송신장치와 수신장치의 송수신방법 또는 통신방법에 대해 상세히 기재하였다.

[132] 실시예들에 따라 다단 구조의 프리코더들 각각에 대해 프리코딩 행렬들을 제한하는 정보들을 결정하고 그 결정한 정보들을 포함하는 코드북제한정보를 전송하므로 코드북제한정보의 전송 오버헤드를 줄일 수 있다. 실시예들에 따라

무선통신시스템에서 코드북제한기법을 사용하므로 셀 간 간섭을 제어할 수 있다.

[133] 전술한 수식학 3을 통해 설명한 바와 같이 프리코딩 행렬의 정의에 따를 때 각 도메인 또는 안테나의 서브세트내에서의 프리코딩 게인은 제1프리코딩 행렬에 의해 결정된다. 즉, 전체 프리코딩 게인은 제1프리코딩 행렬에 대한 이득과 도메인 또는 서브세트간 위상차 보정(co-phasing) 작업을 수행하는 제2프리코더 행렬의 코딩 이득에 의해 결정될 수 있다. 이때 제2프리코딩 행렬은 도메인 또는 서브세트간 위상차 보정(co-phasing) 작업을 수행하는 프리코딩 행렬이므로 각 단말이 획득할 수 있는 최대 프리코딩 게인은 제1프리코딩 행렬에 의해 결정된다. 다시 말해 각 단말이 수신하는 신호의 전력 또는 수신 가능한 최대 전력은 제1프리코더 또는 제1프리코딩 행렬에 의해 결정되며, 제2프리코더 또는 제2프리코딩 행렬은 각 도메인 또는 안테나 서브세트에 수신된 신호의 위상 보정 작업을 수행할 뿐이다. 다중 접속에 의한 간섭은 제1프리코더 또는 제1프리코딩 행렬에 의해 크게 좌우된다.

[134] 도 8 내지 도 10은 실시예들에 따라 무선통신시스템에서 코드북제한기법을 사용하여 셀 간 간섭을 제어하는 개념도들이다.

[135] 도 8을 참조하면, 빔 포밍시 셀 경계 사용자 단말들(810a 내지 810d)은 셀 간 간섭이 발생할 수 있다. 예를 들어 810a 및 810b로 표시된 단말들은 도 8에 도시한 바와 같이 제1기지국과 제2기지국의 커버리지 내에 존재하기 때문에 제1기지국 또는 제1셀(820a)의 PMI_1=4 또는 PMI_1=6에 대한 제1프리코딩 행렬로 프리코딩한 신호 전송시 제2기지국 또는 제2셀(820b)의 PMI_1=13에 대한 제1프리코딩 행렬로 프리코딩한 신호 전송은 간섭을 일으킬 수 있다.

[136] 다시 말해 810a 및 810b로 표시된 단말들은 제1기지국 또는 제1셀(820a)의 PMI_1=4 또는 PMI_1=6에 대한 제1프리코딩 행렬로 프리코딩한 전송 신호와 제2기지국 또는 제2셀(820b)의 PMI_1=13에 대한 제1프리코딩 행렬로 프리코딩한 전송 신호를 모두 수신하므로 간섭을 일으킬 수 있다.

[137] 반대로 810c 및 810d로 표시된 단말들은 도 8에 도시한 바와 같이 제1기지국과 제2기지국의 커버리지 내에 존재하기 때문에 제1기지국(820a)의 PMI_1=8에 대한 제1프리코딩 행렬로 프리코딩한 신호 전송과 제2기지국(820b)의 PMI_1=2 또는 PMI_1=11에 대한 제1프리코딩 행렬로 프리코딩한 신호전송은 간섭을 일으킬 수 있다.

[138] 구체적으로 하나의 단말(810b)을 예를 들어 설명하면, 하나의 단말(810b)은 도 8에 도시한 바와 같이 제1기지국(820a) 또는 제2기지국(820b) 모두로부터 신호를 수신할 수 있다. 제1기지국(820a)은 하나의 단말(810b)에 신호를 전송하기 위하여 PMI_1=6에 해당하는 제1프리코딩 행렬을 사용하여 신호를 전송하며, 제2기지국(820b)은 하나의 단말(810b)에 신호를 전송하기 위하여 PMI_1=13에 해당하는 제1프리코더 행렬을 사용한다. 결과적으로 도 8에 도시한 바와 같이 하나의 단말(810b)에 제2기지국(820b)이 PMI_1=13을 사용하여 신호를 전송할 때

다른 단말(810a)은 하나의 단말(810b)에게 전송된 신호에 의해 다중 접속 간섭을 받게 된다.

[139] 제2기지국(820b)이 PMI_1=13에 해당하는 제1프리코더 행렬을 사용하지 않도록 코드북 제한을 할 경우, 단말(810b)은 제1기지국(820a)으로부터의 신호만을 수신받게 되므로 다중 간섭에 의한 셀 간 간섭을 사전에 방지할 수 있다.

[140] 또다른 단말들(810c, 810d)도 위에서 설명한 단말들(810a, 810b)와 동일한 셀간 간섭에 의한 다중 접속간섭을 받게 된다.

[141] 제1기지국(820a)이 PMI_1=8에 해당하는 제1프리코더 행렬을 사용하지 않도록 코드북 제한을 할 경우, 단말들(810c, 810d)은 제2기지국(820b)로부터 신호만을 수신받게 되므로 다중 간섭에 의한 셀 간 간섭을 사전에 방지할 수 있다.

[142] 도 9는 전술한 방식으로 코드북 제한을 함으로 셀간 간섭을 발생시킬 것이라 예상되는 제1프리코딩 행렬 또는 이에 대한 인덱스에 대하여 제한을 한 후 이에 근거하여 하향링크 MIMO을 수행한 것을 개념적으로 도시하고 있다.

[143] 도 9를 참조하면, 각 기지국들(820a, 820b)이 PMI_1=13과 PMI_1=8 또는 이들에 대응하는 제1프리코딩 행렬의 사용을 제한하는 PMI_1 기반 코드북 제한을 수행할 경우, 도 9에 도시한 바와 같이 셀간 간섭 발생을 피하거나 줄일 수 있다. 따라서, PMI_2에 대해서는 코드북 제한을 가하지 않고 PMI_1에만 코드북 제한을 가할 경우 전술한 셀간 간섭 제거 효과를 얻을 수 있다.

[144] 도 10을 참조하면, 810b로 표시한 단말은 제1기지국의 PMI_1=6과 제2기지국의 PMI_1=13에 대한 제1프리코딩 행렬로 프리코딩된 신호들을 수신하므로 간섭이 발생하고, 810c로 표시한 단말은 제1기지국의 PMI_1=8과 제2기지국의 PMI_1=2에 대한 제1프리코딩 행렬로 프리코딩된 신호들을 수신하므로 간섭이 발생할 수 있다. 이 경우 제1기지국은 PMI_1=6의 사용을 허가하고 PMI_1=2의 사용을 제한하고 반대로 제2기지국은 PMI_1=2의 사용을 허가하고 PMI_1=6의 사용을 제한하므로 단말들의 간섭을 제거할 수 있다.

[145] 다른 방식으로 이 경우 제1기지국은 PMI_1=8의 사용을 허가하고 PMI_1=13의 사용을 제한하고 반대로 제2기지국은 PMI_1=13의 사용을 허가하고 PMI_1=8의 사용을 제한하므로 단말들의 간섭을 제거할 수 있다.

[146] 다른 방식으로 제1기지국은 PMI_1=6과 PMI_1=8의 사용을 허가하고 제2기지국은 PMI_1=6과 PMI_1=8의 사용을 제한할 수도 있고, 반대로 제1기지국은 PMI_1=6과 PMI_1=8의 사용을 제한하고 제2기지국은 PMI_1=6과 PMI_1=8의 사용을 허가하여 단말들의 간섭을 제거할 수 있다.

[147] 이와 같이 각 기지국들(820a, 820b)이 PMI_1 기반 코드북 제한을 수행할 경우, 셀간 간섭 발생을 피하거나 줄일 수 있다. PMI_2에 대해서는 코드북 제한을 가하지 않고 PMI_1에만 코드북 제한을 가할 경우 전술한 셀간 간섭 제거 효과를 얻을 수 있다.

[148] 또한 PMI_2에 대해서만 코드북 제한을 가할 경우, 적은 비트수로 코드북을 제한할 수 있는 장점이 있으며, 프리코딩 게인을 직접적으로 제어하는 PMI_1에

제약을 걸지 않아 보다 정밀한 프리코딩이 가능하면서도 코드북 크기를 줄일 수 있다는 장점이 있다.

[149] 이상 도면을 참조하여 실시예들을 상세히 설명하였으나 본 발명은 이에 제한되지 않는다.

[150] 이상과 같은 실시예들은 상향/하향링크 MIMO 시스템에 적용될 수 있으며, 단일 셀(single cell) 환경뿐 아니라 다중 포인트 협력형 송수신 시스템(Coordinated multi-point transmission/reception System; CoMP) 및 이종 네트웍(heterogeneous network) 등 모든 상향/하향링크 MIMO 시스템에 적용될 수 있을 것이다.

[151] 이상의 설명은 본 발명의 기술 사상을 예시적으로 설명한 것에 불과한 것으로서, 본 발명이 속하는 기술 분야에서 통상의 지식을 가진 자라면 본 발명의 본질적인 특성에서 벗어나지 않는 범위에서 다양한 수정 및 변형이 가능할 것이다. 따라서, 본 발명에 개시된 실시예들은 본 발명의 기술 사상을 한정하기 위한 것이 아니라 설명하기 위한 것이고, 이러한 실시예에 의하여 본 발명의 기술 사상의 범위가 한정되는 것은 아니다. 본 발명의 보호 범위는 아래의 청구범위에 의하여 해석되어야 하며, 그와 동등한 범위 내에 있는 모든 기술 사상은 본 발명의 권리범위에 포함되는 것으로 해석되어야 할 것이다.

[152] **CROSS-REFERENCE TO RELATED APPLICATION**

[153] 본 특허출원은 2010년 7월 5일 한국에 출원한 특허출원번호 제 10-2010-0064573 호에 대해 미국 특허법 119(a)조 (35 U.S.C § 119(a))에 따라 우선권을 주장하며, 그 모든 내용은 참고문헌으로 본 특허출원에 병합된다. 아울러, 본 특허출원은 미국 이외에 국가에 대해서도 위와 동일한 동일한 이유로 우선권을 주장하면 그 모든 내용은 참고문헌으로 본 특허출원에 병합된다.

청구범위

[청구항 1] 제1프리코더와 제2프리코더를 포함하는 송신장치에서,
자신의 코드북에서 각 레이어에 대해 상기 제1프리코더의 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코더의 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보를 각각 결정하는 단계; 및
결정한 상기 제1정보와 상기 제2정보 중 적어도 하나를 포함하는 코드북제한정보를 수신장치에 전송하는 단계를 포함하는 송신장치의 통신방법.

[청구항 2] 제1항에 있어서,
상기 수신장치로부터 상기 수신장치가 상기 코드북제한정보를 이용하여 선택한 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 수신하는 단계; 및
수신한 상기 제1채널상태정보에 대응하는 제1프리코딩 행렬과 상기 제2채널상태정보에 대응하는 제2프리코딩 행렬을 이용하여 상기 제1프리코더와 상기 제2프리코더로 데이터 심볼들을 프리코딩하여 전송하는 단계를 추가로 포함하는 송신장치의 통신방법.

[청구항 3] 제1항에 있어서,
상기 제1정보와 상기 제2정보는 비트맵형식인 것을 특징으로 하는 송신장치의 통신방법.

[청구항 4] 제1항에 있어서,
상기 제1정보에 따라 상기 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고, 상기 제2정보에 따라 상기 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용이 제한되는 것을 특징으로 하는 송신장치의 통신방법.

[청구항 5] 제1항에 있어서,
상기 송신장치는 하나의 방향으로 편파된 적어도 하나의 안테나를 포함하는제1도메인과 다른 방향으로 편파된 적어도 하나의 다른 안테나를 포함하는 제2도메인이 서로 교차하는 적어도 하나의 안테나쌍을 포함하며,
상기 제1프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 별로 각각 프리코딩을 수행하는 프리코딩 행렬이며, 상기 제2프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 간 위상불일치의 영향을 제거하기 위한 위상차 보정을 수행하는 프리코딩 행렬인 것을 특징으로 하는 송신장치의 통신방법.

[청구항 6] 제5항에 있어서,
상기 제1프리코딩 행렬은 아래 수학식의 W1에 해당하며 상기 제2프리코딩 행렬은 아래 수학식의 W2에 해당하는 것을 특징으로 하는 송신장치의 통신방법.

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

상기 수학식에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한 공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 Λ는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

[청구항 7] 제5항에 있어서,
상기 안테나쌍의 개수는 4개인 것을 특징으로 하는 송신장치의 통신방법.

[청구항 8] 제2항에 있어서,
상기 제1채널상태정보와 상기 제2채널상태정보를 수신하는 단계에서, 상기 제1채널상태정보를 수신하는 주기와 상기 제2채널상태정보를 수신하는 주기가 다른 것을 특징으로 하는 송신장치의 통신방법.

[청구항 9] 제8항에 있어서,
상기 제1채널상태정보를 수신하는 주기가 상기 제2채널상태정보를 수신하는 주기보다 긴 것을 특징으로 하는 송신장치의 통신방법.

[청구항 10] 코드워드를 레이어에 매핑하는 레이어 맵퍼;
상기 코드워드가 상기 레이어 맵퍼에 의해 상기 레이어에 매핑된 데이터심볼을 자신의 코드북에서 선택한 제1프리코딩 행렬과 제2프리코딩 행렬을 이용하여 프리코딩하는 제1프리코더와 제2프리코더를 포함하는 프리코더;
프리코더로부터 출력된 신호들을 전송하는 안테나 어레이를 포함하며,
상기 코드워드는, 상기 코드북에서 각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 상기 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하는 송신장치.

[청구항 11] 제10항에 있어서,
상기 안테나 어레이는 제1프리코딩 행렬을 지시하는
제1채널상태정보와 제2프리코딩 행렬을 지시하는
제2채널상태정보를 수신하고,
상기 제1프리코더와 상기 제2프리코더 각각은 수신한 상기
제1채널상태정보에 대응하는 제1프리코딩 행렬과 상기
제2채널상태정보에 대응하는 제2프리코딩 행렬을 이용하여 상기
데이터 심볼들을 프리코딩하는 것을 특징으로 하는 송신장치.

[청구항 12] 제10항에 있어서,
상기 제1정보와 상기 제2정보는 비트맵형식인 것을 특징으로 하는
송신장치.

[청구항 13] 제10항에 있어서,
상기 제1정보에 따라 상기 제1프리코딩 행렬과 쌍을 이루는
제2프리코딩 행렬들의 사용이 제한되고, 상기 제2정보에 따라
상기 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의
사용이 제한되는 것을 특징으로 하는 송신장치.

[청구항 14] 제10항에 있어서,
상기 안테나 어레이는 하나의 방향으로 편파된 적어도 하나의
안테나를 포함하는 제1도메인과 다른 방향으로 편파된 적어도
하나의 다른 안테나를 포함하는 제2도메인이 서로 교차하는
적어도 하나의 안테나쌍을 포함하며,
상기 제1프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 별로
각각 프리코딩을 수행하는 프리코딩 행렬이며, 상기 제2프리코딩
행렬은 상기 제1도메인과 상기 제2도메인 간 위상불일치의 영향을
제거하기 위한 위상차 보정을 수행하는 프리코딩 행렬인 것을
특징으로 하는 송신장치.

[청구항 15] 제14항에 있어서,
상기 제1프리코딩 행렬은 아래 수학식의 W1에 해당하며 상기
제2프리코딩 행렬은 아래 수학식의 W2에 해당하는 것을 특징으로
하는 송신장치.

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

상기 수학식에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한

공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 Δ는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

[청구항 16] 제14항에 있어서,
상기 제1도메인과 상기 제2도메인은 서로 직교하는 것을 특징으로 하는 송신장치.

[청구항 17] 제14항에 있어서,
상기 안테나쌍의 개수는 4개인 것을 특징으로 하는 송신장치.

[청구항 18] 무선통신시스템에서,
각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제2정보 중 적어도 하나를 포함하는 코드북제한정보를 수신하는 수신단계; 및
상기 코드북제한정보를 이용하여 코드북에서 상기 제1프리코딩 행렬 또는 상기 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송하는 전송단계를 포함하는 수신장치의 통신방법.

[청구항 19] 제18항에 있어서,
상기 제1정보와 상기 제2정보는 비트맵형식인 것을 특징으로 하는 수신장치의 통신방법.

[청구항 20] 제18항에 있어서,
상기 제1정보에 따라 상기 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고, 상기 제2정보에 따라 상기 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용이 제한되는 것을 특징으로 하는 수신장치의 통신방법.

[청구항 21] 제18항에 있어서,
상기 송신장치는 하나의 방향으로 편파된 적어도 하나의 안테나를 포함하는제1도메인과 다른 방향으로 편파된 적어도 하나의 다른 안테나를 포함하는 제2도메인이 서로 교차하는 적어도 하나의 안테나쌍을 포함하며,
상기 제1프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 별로 각각 프리코딩을 수행하는 프리코딩 행렬이며, 상기 제2프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 간 위상불일치의 영향을 제거하기 위한 위상차 보정을 수행하는 프리코딩 행렬인 것을 특징으로 하는 수신장치의 통신방법.

[청구항 22] 제21항에 있어서,

상기 제1프리코딩 행렬은 아래 수학식의 W1에 해당하며 상기 제2프리코딩 행렬은 아래 수학식의 W2에 해당하는 것을 특징으로 하는 수신장치의 통신방법.

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

상기 수학식에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한 공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 Λ는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

[청구항 23] 제18항에 있어서,
상기 전송단계에서, 상기 제1채널상태정보를 전송하는 주기와 상기 제2채널상태정보를 전송하는 주기가 다른 것을 특징으로 하는 수신장치의 통신방법.

[청구항 24] 제23항에 있어서,
상기 제1채널상태정보를 전송하는 주기가 상기 제2채널상태정보를 전송하는 주기보다 긴 것을 특징으로 하는 수신장치의 통신방법.

[청구항 25] 무선통신시스템에서,
각 레이어에 대해 제1프리코딩 행렬로 사용되는 것을 제한하는 제1정보와 제2프리코딩 행렬로 사용되는 것을 제한하는 제1정보 중 적어도 하나를 코드북제한정보로 수신하는 안테나 어레이; 및
상기 코드북제한정보를 이용하여 코드북에서 상기 제1프리코딩 행렬 또는 상기 제2프리코딩 행렬로 사용되는 것을 제한하지 않은 프리코딩 행렬들에서 선택된 제1프리코딩 행렬을 지시하는 제1채널상태정보와 제2프리코딩 행렬을 지시하는 제2채널상태정보를 송신장치에 전송하는 채널정보 피드백장치를 포함하는 수신장치.

[청구항 26] 제25항에 있어서,
상기 제1정보와 상기 제2정보는 비트맵형식인 것을 특징으로 하는 수신장치.

[청구항 27] 제25항에 있어서,
상기 제1정보에 따라 상기 제1프리코딩 행렬과 쌍을 이루는 제2프리코딩 행렬들의 사용이 제한되고, 상기 제2정보에 따라

상기 제2프리코딩 행렬과 쌍을 이루는 제1프리코딩 행렬들의 사용이 제한되는 것을 특징으로 하는 수신장치.

[청구항 28] 제25항에 있어서,
상기 송신장치는 하나의 방향으로 편파된 적어도 하나의 안테나를 포함하는제1도메인과 다른 방향으로 편파된 적어도 하나의 다른 안테나를 포함하는 제2도메인이 서로 교차하는 적어도 하나의 안테나쌍을 포함하며,
상기 제1프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 별로 각각 프리코딩을 수행하는 프리코딩 행렬이며, 상기 제2프리코딩 행렬은 상기 제1도메인과 상기 제2도메인 간 위상불일치의 영향을 제거하기 위한 위상차 보정을 수행하는 프리코딩 행렬인 것을 특징으로 하는 수신장치.

[청구항 29] 제28항에 있어서,
상기 제1프리코딩 행렬은 아래 수학식의 W1에 해당하며 상기 제2프리코딩 행렬은 아래 수학식의 W2에 해당하는 것을 특징으로 하는 수신장치.

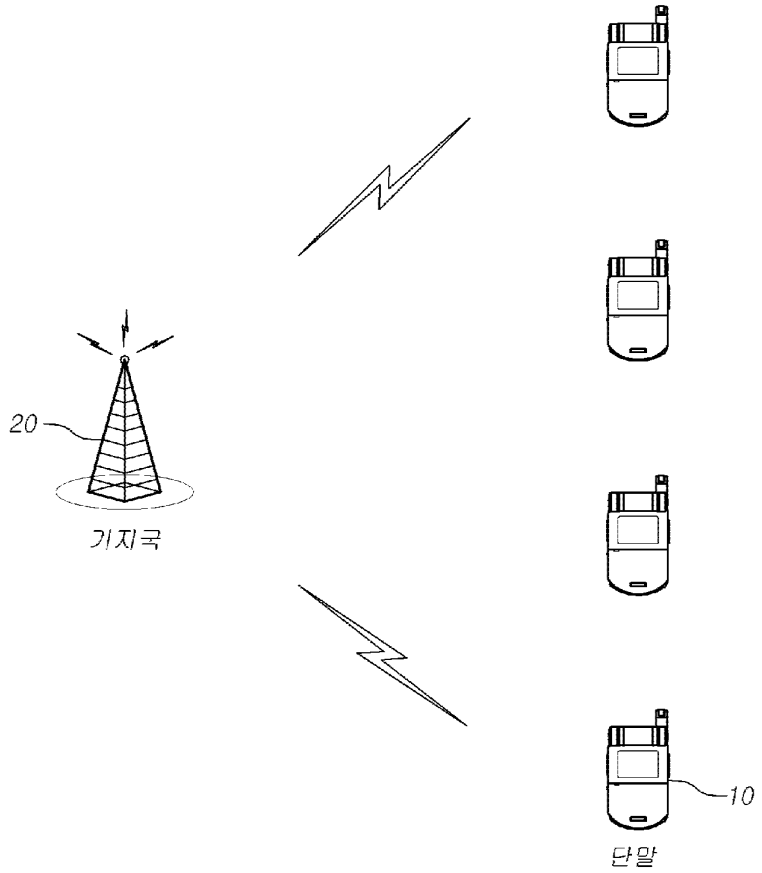
$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2}$$

상기 수학식에서 R_0는 상기 제1도메인과 상기 제2도메인이 동일한 공간적 채널 상태를 가질 경우 프리코딩 게인에 의해 결정되는 값이며, I는 단위 행렬이며 Λ는 상기 제1도메인과 상기 제2도메인 간 위상차 보정값이다.

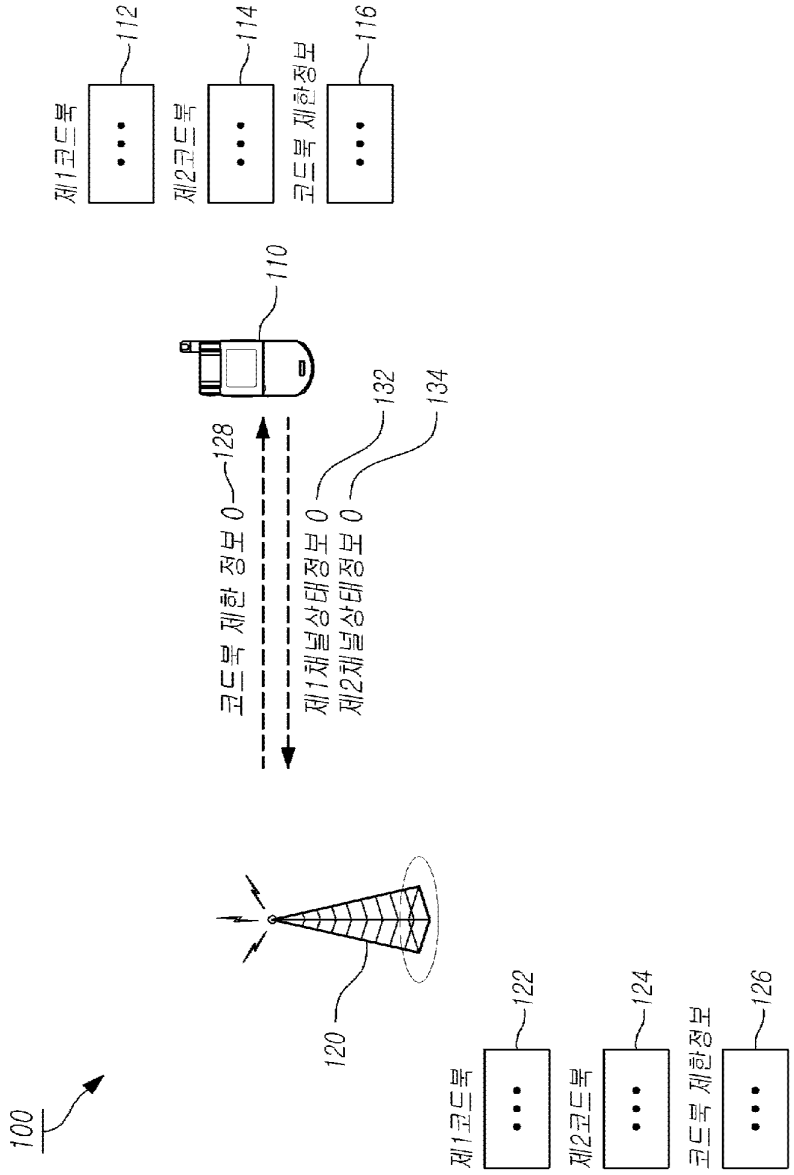
[청구항 30] 제25항에 있어서,
상기 제1채널상태정보를 전송하는 주기와 상기 제2채널상태정보를 전송하는 주기가 다른 것을 특징으로 하는 수신장치.

[청구항 31] 제30항에 있어서,
상기 제1채널상태정보를 전송하는 주기가 상기 제2채널상태정보를 전송하는 주기보다 긴 것을 특징으로 하는 수신장치.

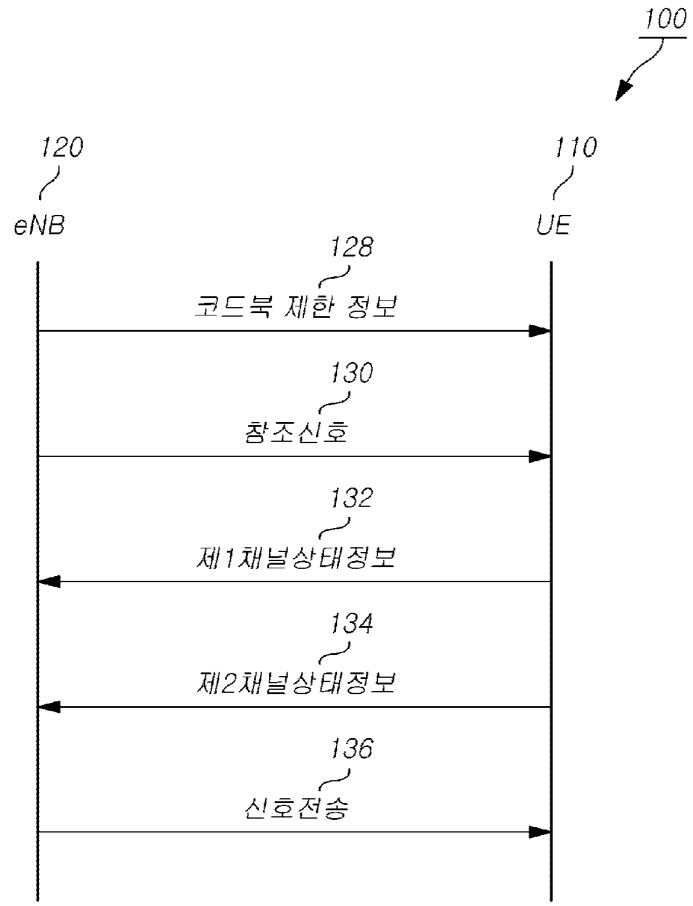
[Fig. 1]



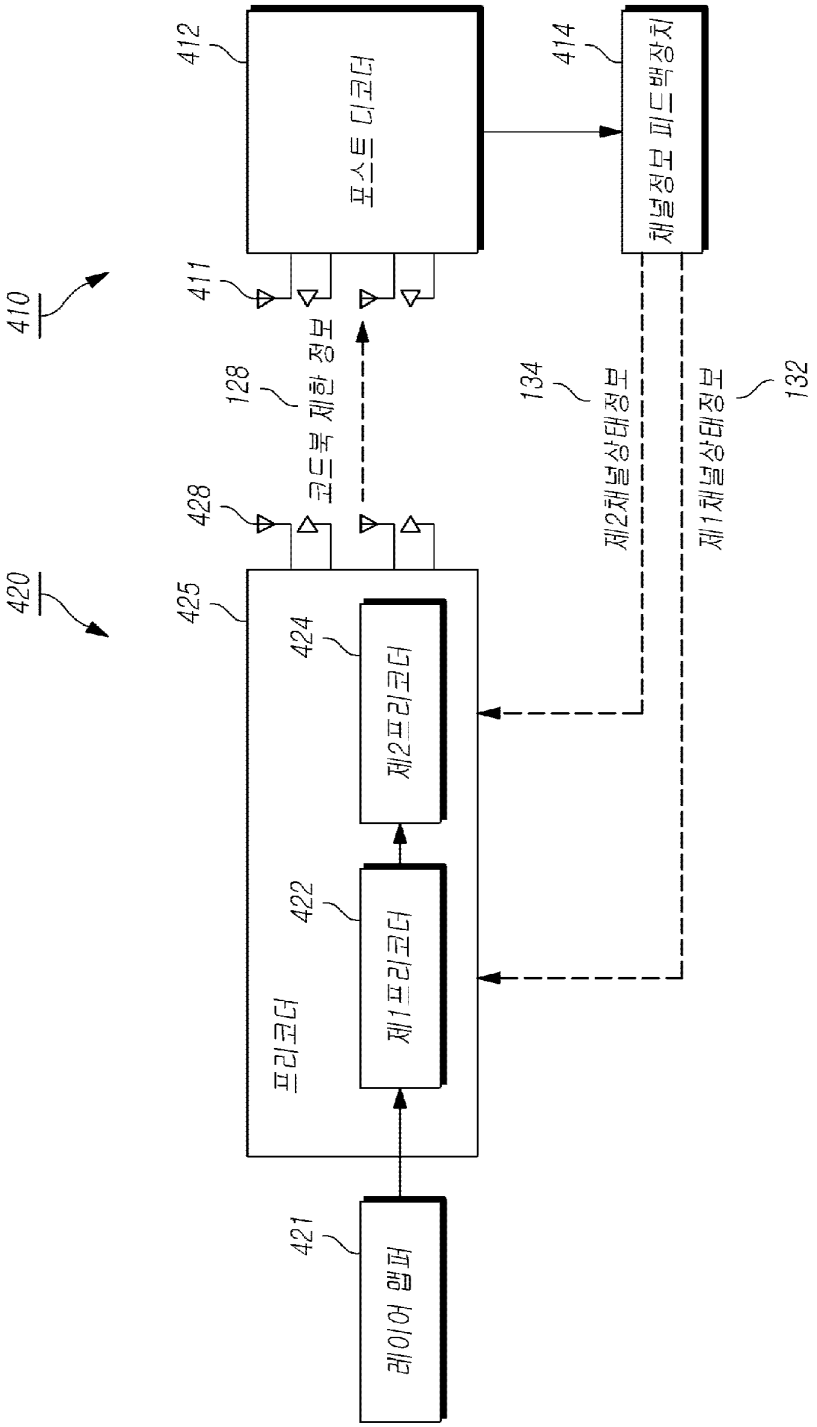
[Fig. 2]


112
114
116
제1코드북
제2코드북
코드북 제한정보
110
128
132
134
코드북 제한 정보 0
제1채널상태정보 0
제2채널상태정보 0
120
122
124
126
제1코드북
제2코드북
코드북 제한정보
100

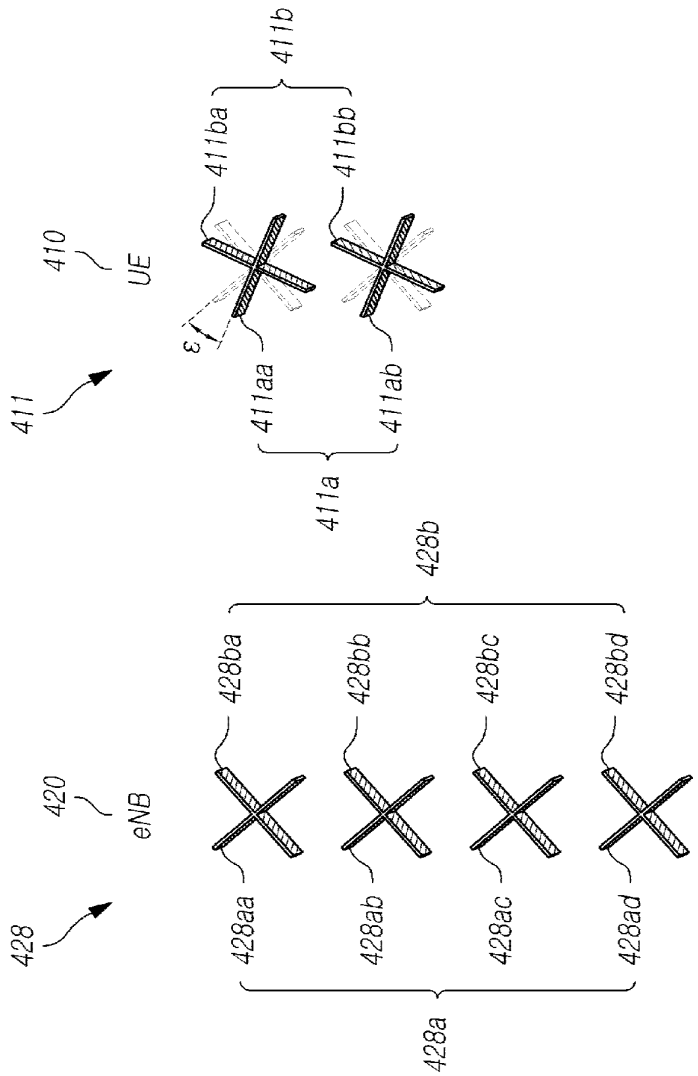
[Fig. 3]


100
120
eNB
110
UE
128
코드북 제한 정보
130
참조신호
132
제1채널상태정보
134
제2채널상태정보
136
신호전송

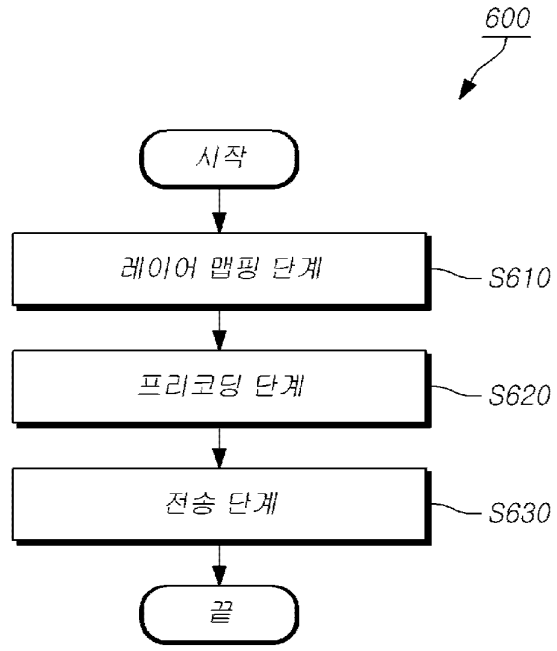
[Fig. 4]


410
411
412
414
420
421
422
424
425
428
128
132
134
포스트 디코더
채널정보 피드백장치
코드북 제한 정보
제2채널상태정보
제1채널상태정보
프리코더
제2프리코더
제1프리코더
레이어 맵퍼

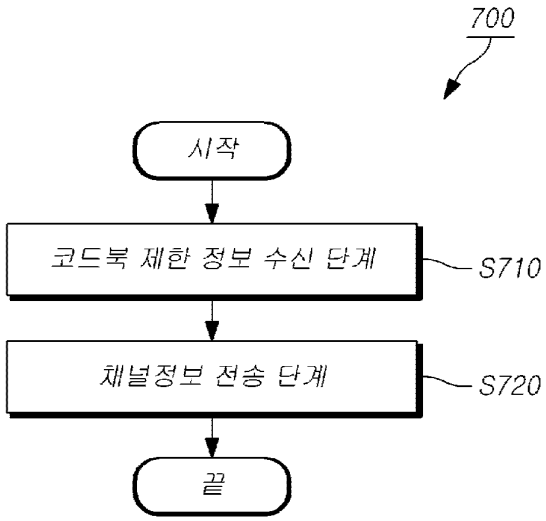
[Fig. 5]


411b
411ba
411bb
410
UE
ε
411
411aa
411ab
411a
428b
428ba
428bb
428bc
428bd
420
eNB
428
428aa
428ab
428ac
428ad
428a

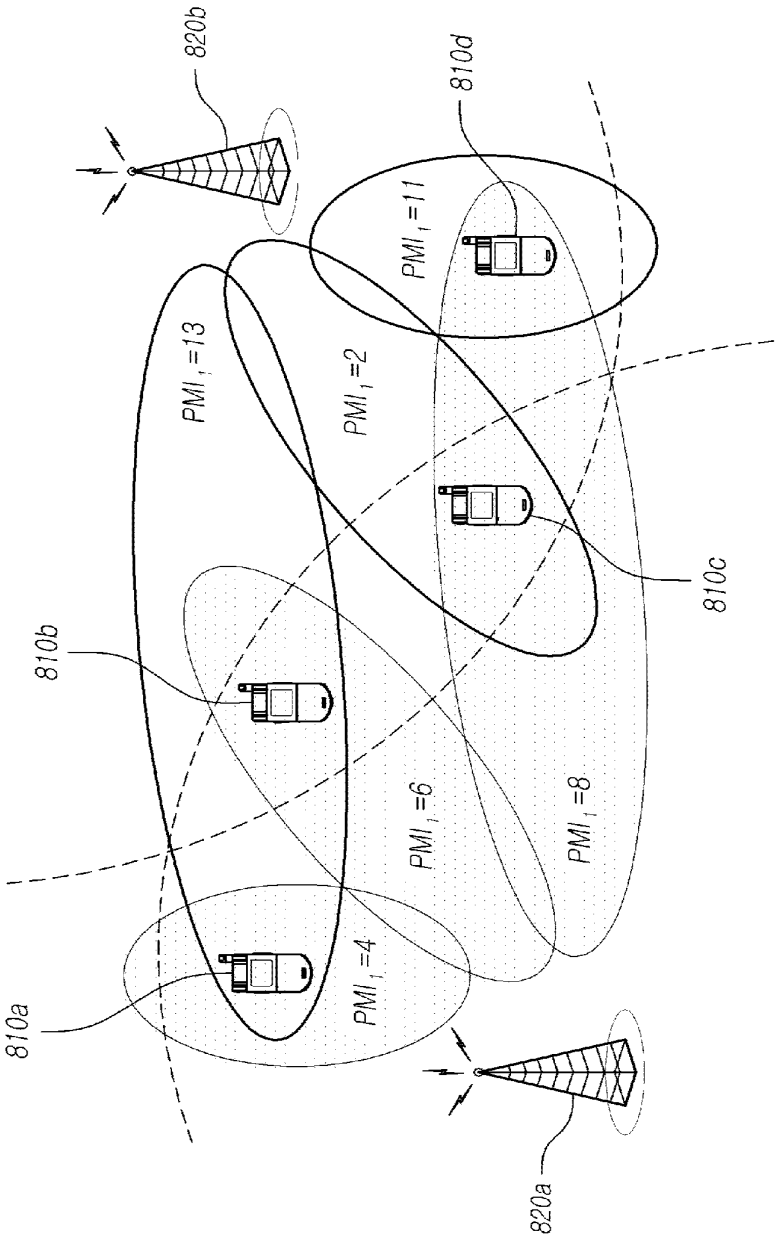
[Fig. 6]


600
시작
레이어 맵핑 단계
S610
프리코딩 단계
S620
전송 단계
S630
끝

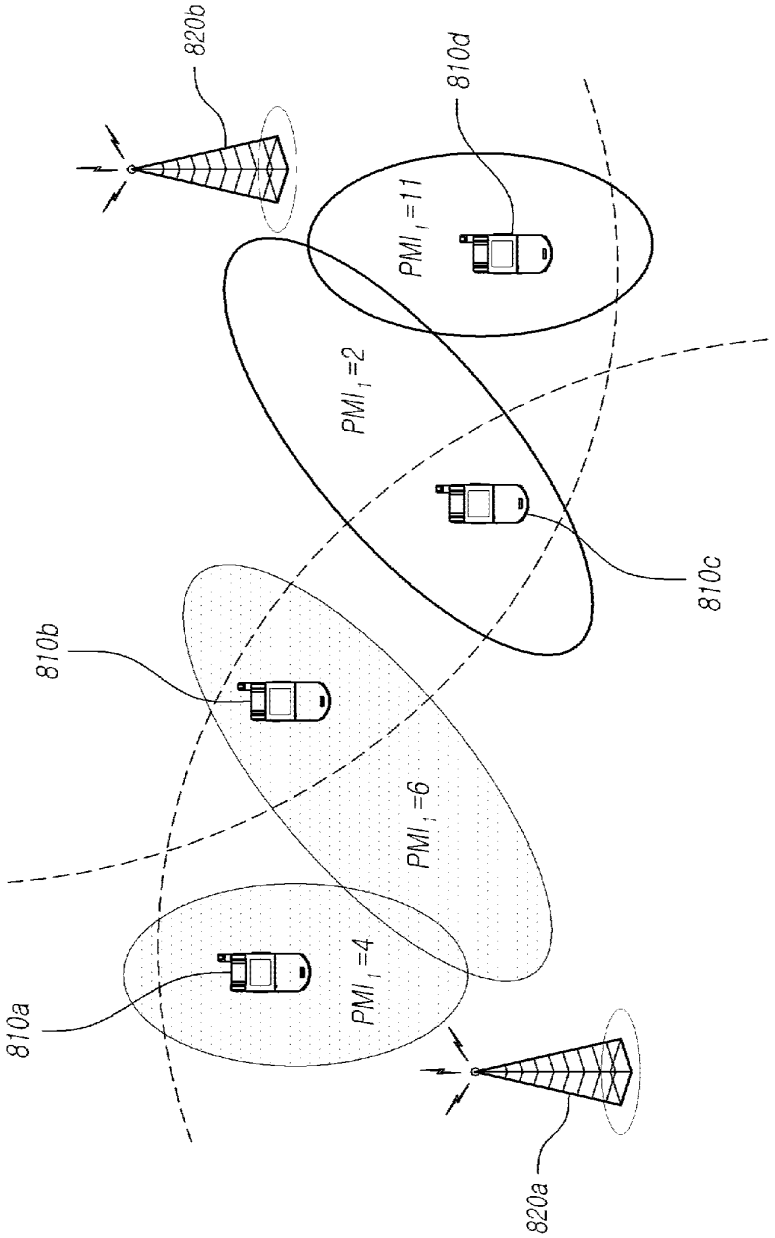
[Fig. 7]



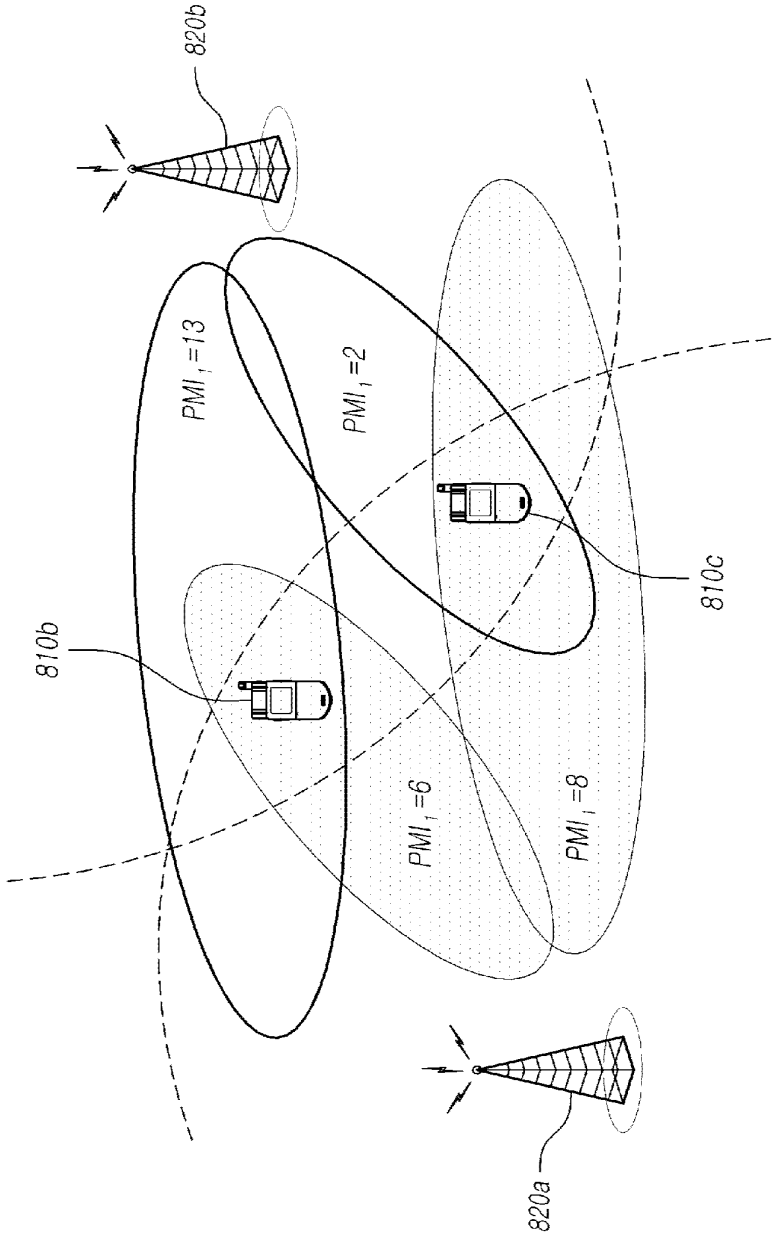
[Fig. 8]


820b
810d
PMI1=11
PMI1=13
PMI1=2
810c
810b
PMI1=6
PMI1=8
PMI1=4
810a
820a

[Fig. 9]



[Fig. 10]



(12) 특허협력조약에 의하여 공개된 국제출원

(19) 세계지식재산권기구
국제사무국

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(72) 발명자; 겸
(75) 발명자/출원인 (US 에 한하여): **박경민 (PARK, Kyoungmin)** [KR/KR]; 서울시 마포구 상암동 DMC, I-2, 팬택빌딩, 121-270 Seoul (KR).

(74) 대리인: **김은구 (KIM, Eungu)** 등; 서울특별시 강남구 역삼동 636-15 상원빌딩 2 층, 135-908 Seoul (KR).

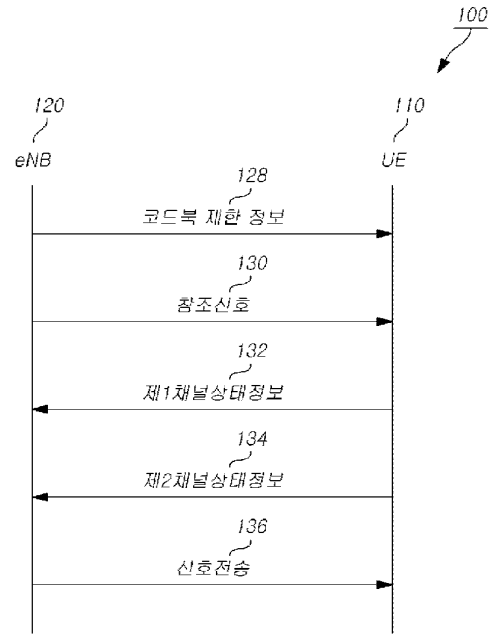
(81) 지정국 (별도의 표시가 없는 한, 가능한 모든 종류의 국내 권리의 보호를 위하여): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG,

[다음 쪽 계속]

(54) **Title**: TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

(54) **발명의 명칭** : 송신장치 및 그 통신방법, 수신장치, 그 통신방법

[Fig. 3]



120 ... eNB
110 ... UE
128 ... Codebook restriction information
130 ... Reference signal
132 ... 1st Channel status information
134 ... 2nd Channel status information
136 ... Signal transmission

(57) **Abstract**: An embodiment of the present invention relates to a wireless communication system, and more specifically relates to a wireless communication system using multi-input and multi-output (MIMO) antennas in all transmission and reception terminals.

(57) **요약서**: 이 출원은 송수신단 모두에서 다중입력다중출력 (MIM0) 안테나를 이용하는 무선통신시스템에 관한 것이다. 특히, 제 1 프리코더와제 2 프리코더를 포함하는 송신장치에서 자신의 코드북에서 각 레이어에 대해 상기 제 1 프리코더의 제 1 프리코딩 행렬로사용되는 것을 제한하는 제 1 정보와 상기 제 2 프리 코더의 제 2 프리코딩 행렬로 사용되는 것을 제한하는 제 2 정보를 각각 결정하는 단계 및 결정한 상기 제 1 정보와상기 제 2 정보 중 적어도 하나를 포함하는 코드북 제한정보를 수신장치에 전송하는 단계를 기술적 특징으로 포함하고 있다.

WO 2012/005476 A3

SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **지정국** (별도의 표시가 없는 한, 가능한 모든 종류의 역내 권리의 보호를 위하여): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), 유라시아 (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), 유럽 (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, ML, MR, NE, SN, TD, TG).

공개:

— 국제조사보고서와 함께 (조약 제 21 조(3))

— 청구범위 보정 기한 만료 전의 공개이며, 보정서를 접수하는 경우 그에 관하여 별도 공개함 (규칙 48.2(h))

(88) **국제조사보고서 공개일**: 2012 년 3 월 1 일

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2011/004835

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 7/04; H04L 27/28; H04B 15/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

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

eKOMPASS (KIPO internal) & Keywords: code book, restriction, precoder, wireless communication

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010-0048233 A1 (KIM, YU-SEOK et al.) 25 February 2010 See abstract, paragraph [50] - paragraph [52] and figure 6.	1-31
A	WO 2009-125956 A1 (LG ELECTRONICS INC. et al.) 15 October 2009 See abstract and claim 1.	1-31
PX PA	US 2011-0116563 A1 (VITTHALADEVUNI PAVAN KUMAR et al.) 19 May 2011 See abstract, paragraph [78] - paragraph [79] and figures 19,20.	1,10,18,25 2-9,11-17,19-24 ,26-31

☐ 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	Date of mailing of the international search report
28 DECEMBER2011 (28.12.2011)	**28 DECEMBER2011 (28.12.2011)**

Name and mailing address of the ISA/KR
Korean Intellectual Property Office
Government Complex-Daejeon, 139 Seonsa-ro, Daejeon 302-701, Republic of Korea
Facsimile No. 82-42-472-7140

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

Patent document cited in search report	Publication date	Patent family member	Publication date
US 2010-0048233 A1	25.02.2010	KR 10-2010-0023529 A	04.03.2010
WO 2009-125956 A1	15.10.2009	CN 101981823 A	23.02.2011
		CN 101981824 A	23.02.2011
		CN 101981825 A	23.02.2011
		EP 2245758 A1	03.11.2010
		EP 2248277 A1	10.11.2010
		EP 2248278 A1	10.11.2010
		EP 2340620 A2	06.07.2011
		JP 2011-517524 A	09.06.2011
		JP 2011-518491 A	23.06.2011
		JP 2011-518492 A	23.06.2011
		KR 10-2009-0106975 A	12.10.2009
		KR 10-2010-0048845 A	11.05.2010
		US 2009-0257383 A1	15.10.2009
		US 2009-0257384 A1	15.10.2009
		US 2009-0268698 A1	29.10.2009
		US 2010-0118997 A1	13.05.2010
		US 8045528 B2	25.10.2011
		WO 2009-125954 A1	15.10.2009
		WO 2009-125955 A1	15.10.2009
		WO 2010-050689 A2	06.05.2010
US 2011-0116563 A1	19.05.2011	WO 2011-060299 A2	19.05.2011
		WO 2011-060299 A3	25.08.2011

국 제 조 사 보 고 서

국제출원번호
PCT/KR2011/004835

A. 발명이 속하는 기술분류(국제특허분류(IPC))

H04B 7/04(2006.01)i

B. 조사된 분야

조사된 최소문헌(국제특허분류를 기재)
H04B 7/04; H04L 27/28; H04B 15/00

조사된 기술분야에 속하는 최소문헌 이외의 문헌
한국등록실용신안공보 및 한국공개실용신안공보: 조사된 최소문헌란에 기재된 IPC
일본등록실용신안공보 및 일본공개실용신안공보: 조사된 최소문헌란에 기재된 IPC

국제조사에 이용된 전산 데이터베이스(데이터베이스의 명칭 및 검색어(해당하는 경우))
eKOMPASS(특허청 내부 검색시스템) & 키워드: 코드북, 제한, 프리코더, 무선통신

C. 관련 문헌

카테고리*	인용문헌명 및 관련 구절(해당하는 경우)의 기재	관련 청구항
A	US 2010-0048233 A1 (KIM YU-SEOK 외 4명) 2010.02.25 요약, 문단 [50] - 문단 [52] 및 도 6 참조.	1-31
A	WO 2009-125956 A1 (LG ELECTRONICS INC. 외 6명) 2009.10.15 요약 및 청구항 1항 참조.	1-31
PX PA	US 2011-0116563 A1 (VITTHALADEVUNI PAVAN KUMAR 외 2명) 2011.05.19 요약, 문단 [78] - 문단 [79] 및 도 19,20 참조.	1,10,18,25 2-9,11-17,19-24 ,26-31

☐ 추가 문헌이 C(계속)에 기재되어 있습니다.

☒ 대응특허에 관한 별지를 참조하십시오.

* 인용된 문헌의 특별 카테고리:

"A" 특별히 관련이 없는 것으로 보이는 일반적인 기술수준을 정의한 문헌

"E" 국제출원일보다 빠른 출원일 또는 우선일을 가지나 국제출원일 이후에 공개된 선출원 또는 특허 문헌

"L" 우선권 주장에 의문을 제기하는 문헌 또는 다른 인용문헌의 공개일 또는 다른 특별한 이유(이유를 명시)를 밝히기 위하여 인용된 문헌

"O" 구두 개시, 사용, 전시 또는 기타 수단을 언급하고 있는 문헌

"P" 우선일 이후에 공개되었으나 국제출원일 이전에 공개된 문헌

"T" 국제출원일 또는 우선일 후에 공개된 문헌으로, 출원과 상충하지 않으며 발명의 기초가 되는 원리나 이론을 이해하기 위해 인용된 문헌

"X" 특별한 관련이 있는 문헌. 해당 문헌 하나만으로 청구된 발명의 신규성 또는 진보성이 없는 것으로 본다.

"Y" 특별한 관련이 있는 문헌. 해당 문헌이 하나 이상의 다른 문헌과 조합하는 경우로 그 조합이 당업자에게 자명한 경우 청구된 발명은 진보성이 없는 것으로 본다.

"&" 동일한 대응특허문헌에 속하는 문헌

국제조사의 실제 완료일	국제조사보고서 발송일
2011년 12월 28일 (28.12.2011)	**2011년 12월 28일 (28.12.2011)**

ISA/KR의 명칭 및 우편주소
대한민국 특허청
(302-701) 대전광역시 서구 청사로 189,
정부대전청사
팩스 번호 82-42-472-7140

심사관
김병성
전화번호 82-42-481-5652

서식 PCT/ISA/210 (두 번째 용지) (2009년 7월)

국 제 조 사 보 고 서
대응특허에 관한 정보

국제출원번호
PCT/KR2011/004835

국제조사보고서에서 인용된 특허문헌	공개일	대응특허문헌	공개일
US 2010-0048233 A1	2010.02.25	KR 10-2010-0023529 A	2010.03.04
WO 2009-125956 A1	2009.10.15	CN 101981823 A	2011.02.23
		CN 101981824 A	2011.02.23
		CN 101981825 A	2011.02.23
		EP 2245758 A1	2010.11.03
		EP 2248277 A1	2010.11.10
		EP 2248278 A1	2010.11.10
		EP 2340620 A2	2011.07.06
		JP 2011-517524 A	2011.06.09
		JP 2011-518491 A	2011.06.23
		JP 2011-518492 A	2011.06.23
		KR 10-2009-0106975 A	2009.10.12
		KR 10-2010-0048845 A	2010.05.11
		US 2009-0257383 A1	2009.10.15
		US 2009-0257384 A1	2009.10.15
		US 2009-0268698 A1	2009.10.29
		US 2010-0118997 A1	2010.05.13
		US 8045528 B2	2011.10.25
		WO 2009-125954 A1	2009.10.15
		WO 2009-125955 A1	2009.10.15
		WO 2010-050689 A2	2010.05.06
US 2011-0116563 A1	2011.05.19	WO 2011-060299 A2	2011.05.19
		WO 2011-060299 A3	2011.08.25

Document code: WFEE

United States Patent and Trademark Office
Sales Receipt for Accounting Date: 01/23/2013

RJONE1 ADJ #00000002 Mailroom Dt: 12/28/2012
Seq No: 6470 Sales Acctg Dt: 12/31/2012 13807706
04 FC : 1681 -640.00 OP

Document code: WFEE

United States Patent and Trademark Office
Sales Receipt for Accounting Date: 01/23/2013

RJONE1 RF #30120903 Mailroom Dt: 01/23/2013 13807706

Credit Card Refund Total: $640.00

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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

U.S. APPLICATION NUMBER NO.	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
13/807,706	Kyoungmin Park	P5158US00

58027
H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191

INTERNATIONAL APPLICATION NO.	
PCT/KR2011/004835	
I.A. FILING DATE	PRIORITY DATE
07/01/2011	07/05/2010

CONFIRMATION NO. 9187
371 ACCEPTANCE LETTER

OC000000058821402

Date Mailed: 01/25/2013

NOTICE OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C 371 AND 37 CFR 1.495

The applicant is hereby advised that the United States Patent and Trademark Office in its capacity as a Designated / Elected Office (37 CFR 1.495), has determined that the above identified international application has met the requirements of 35 U.S.C. 371, and is ACCEPTED for national patentability examination in the United States Patent and Trademark Office.

The United States Application Number assigned to the application is shown above and the relevant dates are:

12/28/2012	12/28/2012
DATE OF RECEIPT OF 35 U.S.C. 371(c)(1), (c)(2) and (c)(4) REQUIREMENTS	DATE OF COMPLETION OF ALL 35 U.S.C. 371 REQUIREMENTS

A Filing Receipt (PTO-103X) will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE " FILING DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371 (c)(1), (c)(2) and (c)(4) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN ABOVE.** *The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363).* Once the Filing Receipt has been received, send all correspondence to the Group Art Unit designated thereon.

The following items have been received:

- Copy of the International Application filed on 12/28/2012
- English Translation of the IA filed on 12/28/2012
- Copy of the International Search Report filed on 12/28/2012
- Preliminary Amendments filed on 12/28/2012
- Information Disclosure Statements filed on 12/28/2012
- Oath or Declaration filed on 12/28/2012
- Request for Immediate Examination filed on 12/28/2012
- U.S. Basic National Fees filed on 12/28/2012
- Substitute Specification filed on 12/28/2012
- Priority Documents filed on 12/28/2012
- Power of Attorney filed on 12/28/2012
- Non-English Language Application filed on 12/28/2012
- Authorization to Permit Access filed on 12/28/2012

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

RODERICK M JONES

Telephone: (571) 272-9083

FORM PCT/DO/EO/903 (371 Acceptance Notice)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/807,706	12/28/2012		2072	P5158US00	31	4

CONFIRMATION NO. 9187

58027
H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191

FILING RECEIPT

OC000000058821401

Date Mailed: 01/25/2013

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)
Kyoungmin Park, Seoul, KOREA, REPUBLIC OF;

Applicant(s)
Kyoungmin Park, Seoul, KOREA, REPUBLIC OF;

Assignment For Published Patent Application
Pantech Co., Ltd., Seoul, KOREA, REPUBLIC OF

Power of Attorney: The patent practitioners associated with Customer Number 58027

Domestic Priority data as claimed by applicant
This application is a 371 of PCT/KR2011/004835 07/01/2011

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
REPUBLIC OF KOREA 10-2010-0064573 07/05/2010

Permission to Access - A proper **Authorization to Permit Access to Application by Participating Offices** (PTO/SB/39 or its equivalent) has been received by the USPTO.

If Required, Foreign Filing License Granted: 01/23/2013

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/807,706**

Projected Publication Date: 371 Perfected

Non-Publication Request: No

Early Publication Request: No

Title

TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

Preliminary Class

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as

set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 13/807,706

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	390
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	500
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	250
TOTAL CLAIMS (37 CFR 1.16(i))	31 minus 20 =	* 11			OR	x 62 =	682
INDEPENDENT CLAIMS (37 CFR 1.16(h))	4 minus 3 =	* 1				x 250 =	250
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	2072

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

MULTIPLE DEPENDENT CLAIM FEE CALCULATION SHEET

Substitute for Form PTO-1360
(For use with Form PTO/SB/06)

Application Number	Filing Date
13807706	

Applicant(s) Kyoungmin PARK

* May be used for additional claims or amendments

CLAIMS	AS FILED		AFTER FIRST AMENDMENT		AFTER SECOND AMENDMENT	
	Indep	Depend	Indep	Depend	Indep	Depend
1	1					
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Total Indep	4		0		0	
Total Depend	27	↵	0	↵	0	↵
Total Claims	31		0		0	

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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

U.S. APPLICATION NUMBER NO.	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
13/807,706	Kyoungmin Park	P5158US00

58027
H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191

INTERNATIONAL APPLICATION NO.	
PCT/KR2011/004835	
I.A. FILING DATE	PRIORITY DATE
07/01/2011	07/05/2010

CONFIRMATION NO. 9187
371 ACCEPTANCE LETTER

OC000000058821402

Date Mailed: 01/30/2013

NOTICE OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C 371 AND 37 CFR 1.495

The applicant is hereby advised that the United States Patent and Trademark Office in its capacity as a Designated / Elected Office (37 CFR 1.495), has determined that the above identified international application has met the requirements of 35 U.S.C. 371, and is ACCEPTED for national patentability examination in the United States Patent and Trademark Office.

The United States Application Number assigned to the application is shown above and the relevant dates are:

12/28/2012	12/28/2012
DATE OF RECEIPT OF 35 U.S.C. 371(c)(1), (c)(2) and (c)(4) REQUIREMENTS	DATE OF COMPLETION OF ALL 35 U.S.C. 371 REQUIREMENTS

A Filing Receipt (PTO-103X) will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE " FILING DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371 (c)(1), (c)(2) and (c)(4) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN ABOVE.** *The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363).* Once the Filing Receipt has been received, send all correspondence to the Group Art Unit designated thereon.

The following items have been received:

- Copy of the International Application filed on 12/28/2012
- English Translation of the IA filed on 12/28/2012
- Copy of the International Search Report filed on 12/28/2012
- Preliminary Amendments filed on 12/28/2012
- Information Disclosure Statements filed on 12/28/2012
- Oath or Declaration filed on 12/28/2012
- Request for Immediate Examination filed on 12/28/2012
- U.S. Basic National Fees filed on 12/28/2012
- Substitute Specification filed on 12/28/2012
- Priority Documents filed on 12/28/2012
- Power of Attorney filed on 12/28/2012
- Non-English Language Application filed on 12/28/2012
- Authorization to Permit Access filed on 12/28/2012

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

RODERICK M JONES

Telephone: (571) 272-9083

FORM PCT/DO/EO/903 (371 Acceptance Notice)

MULTIPLE DEPENDENT CLAIM FEE CALCULATION SHEET

Substitute for Form PTO-1360
(For use with Form PTO/SB/06)

Application Number	Filing Date
13807706	

Applicant(s) Kyoungmin PARK

* May be used for additional claims or amendments

CLAIMS	AS FILED		AFTER FIRST AMENDMENT		AFTER SECOND AMENDMENT	
	Indep	Depend	Indep	Depend	Indep	Depend
1	1					
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Total Indep	4		0		0	
Total Depend	27	↵	0	↵	0	↵
Total Claims	31		0		0	

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 13/807,706

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	390
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	500
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	250
TOTAL CLAIMS (37 CFR 1.16(i))	31 minus 20 =	* 11			OR	x 62 =	682
INDEPENDENT CLAIMS (37 CFR 1.16(h))	4 minus 3 =	* 1				x 250 =	250
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	2072

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/807,706	12/28/2012		2072	P5158US00	31	4

CONFIRMATION NO. 9187

58027
H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191

FILING RECEIPT

OC000000058821401

Date Mailed: 01/30/2013

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)
Kyoungmin Park, Seoul, KOREA, REPUBLIC OF;

Applicant(s)
Kyoungmin Park, Seoul, KOREA, REPUBLIC OF;

Assignment For Published Patent Application
Pantech Co., Ltd., Seoul, KOREA, REPUBLIC OF

Power of Attorney: The patent practitioners associated with Customer Number 58027

Domestic Priority data as claimed by applicant
This application is a 371 of PCT/KR2011/004835 07/01/2011

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
REPUBLIC OF KOREA 10-2010-0064573 07/05/2010

Permission to Access - A proper **Authorization to Permit Access to Application by Participating Offices** (PTO/SB/39 or its equivalent) has been received by the USPTO.

If Required, Foreign Filing License Granted: 01/23/2013

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/807,706**

Projected Publication Date: 05/09/2013

Non-Publication Request: No

Early Publication Request: No

Title

TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

Preliminary Class

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as

set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/807,706	12/28/2012	Kyoungmin Park	P5158US00

CONFIRMATION NO. 9187

58027
H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191

PUBLICATION NOTICE

OC000000061096383

Title:TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

Publication No.US-2013-0114763-A1
Publication Date:05/09/2013

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/807,706	12/28/2012	Kyoungmin Park	P5158US00	9187

58027 7590 06/02/2014

H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191

EXAMINER	
LAM, KENNETH T	

ART UNIT	PAPER NUMBER
2631	

NOTIFICATION DATE	DELIVERY MODE
06/02/2014	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

PATENT@PARK-LAW.COM

Office Action Summary	Application No. 13/807,706	Applicant(s) PARK, KYOUNGMIN	
	Examiner KENNETH LAM	Art Unit 2631	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *12/28/2012*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1-31* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-5,7,10-14,16-21 and 25-28* is/are rejected.

8)☒ Claim(s) *6,8,9,15,22-24 and 29-31* is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☒ The drawing(s) filed on *12/28/2012* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☒ All b)☐ Some** c)☐ None of the:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

DETAILED ACTION

1. The present application is being examined under the pre-AIA first to invent provisions.

Claim Rejections - 35 USC § 103

2. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under pre-AIA 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

3. Claims 1-4, 10-13, 18-20, 25-27 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Hammarwall et al. (US 2011/0249713 A1) (Hammarwall herein after).

Re Claim 1, Hammarwall discloses a communication method of a transmitting device including a first precoder and a second precoder, the method comprising:

determining first information (SU-MIMO mode value) to restrict a precoding matrix from being used as a first precoding matrix of the first precoder (mode indicator, [0062], conversion precoder, [0058]), and second information (MU-MIMO mode value) to restrict a precoding matrix from being used as the second precoding matrix of a second precoder (tuning precoder, [0058]) in a corresponding codebook with respect to each layer (mode indicator, rank information, [0062], [0091]); and

transmitting, to a receiving device, codebook restricting information (restriction signal, [0062]) including at least one of the determined first information and second information.

Hammarwall discloses the claimed invention except explicitly teaches the terms of first and second information. However, it would have been obvious to one skilled in the art at the time the invention was made to utilize the teaching by Hammarwall to achieve the same expected results.

Re Claim 2, Hammarwall discloses the method of claim 1, further comprising:

receiving, from the receiving device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix (transceiver 12 receive restriction signal, [0062]), the first precoding matrix and the second precoding matrix selected by the receiving device based on the codebook restricting information (PMI values, [0061]); and

precoding data symbols through the first precoder and the second precoder using the first precoding matrix corresponding to the received 1st channel status information and the second precoding matrix corresponding to the second status information (conversion precoder, tuning precoder, [0058], CSI, [0113]-[0114]), and transmitting the precoded data symbols.

Re Claim 3, Hammarwall discloses the method of claim 1, wherein the first information and the second information are provided in a bitmap format (bitmap-based signaling, [0010]).

Re Claim 4, Hammarwall discloses the method of claim 1, wherein the use of second precoding matrices that make pairs with the first precoding matrix is restricted based on the first information, and the use of first precoding matrices that make pairs with the second precoding matrix is restricted (mode indicator, rank information, [0062], [0091]).

Re Claim 10, Hammarwall discloses a transmitting device, the device comprising:

a layer mapper to map a codeword to a layer (layer processing circuitry, [0092]);

a precoder including a first precoder (mode indicator, [0062], conversion precoder, [0058]) and a second precoder (tuning precoder, [0058]) that performs precoding on a data symbol corresponding to the codeword mapped to the layer by the

layer mapper, using a first precoding matrix and a second precoding matrix selected from a corresponding codebook (PMI values, [0061]); and

an antenna array to transmit signals output from the precoder, wherein the codeword includes at least one of first information (SU-MIMO mode value) to restrict a precoding matrix from being used as the first precoding matrix and second information (MU-MIMO mode value) to restrict a precoding matrix from being used as the second precoding matrix in the corresponding codebook with respect to each layer (mode indicator, rank information, [0062], [0091]).

Hammarwall discloses the claimed invention except explicitly teaches the terms of first and second information. However, it would have been obvious to one skilled in the art at the time the invention was made to utilize the teaching by Hammarwall to achieve the same expected results.

Re Claim 11, Hammarwall discloses the device of claim 10, wherein the antenna array receives 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding matrix (transceiver 12 receive restriction signal, [0062]); and

the first precoder and the second precoder perform precoding on data symbols using the first precoding matrix corresponding to the received 1st channel status information and the second precoding matrix corresponding to the received 2nd channel status information (conversion precoder, tuning precoder, [0058], CSI, [0113]-[0114]),

respectively.

Re Claim 12, Hammarwall discloses the device of claim 10, wherein the first information and the second information are provided in a bitmap format (bitmap-based signaling, [0010]).

Re Claim 13, Hammarwall discloses the device of claim 10, wherein the use of second precoding matrices that make pairs with the first precoding matrix is restricted based on the first information, and the use of first precoding matrices that make pairs with the second precoding matrix is restricted based on the second information (mode indicator, rank information, [0062], [0091]).

Re Claims 18 and 25, Hammarwall discloses a communication method of a receiving device in a wireless communication system and a receiving device in a wireless communication system, the method and the device comprising:

receiving codebook restricting information including at least one of first information (SU-MIMO mode value) to restrict a precoding matrix from being used as a first precoding matrix and second information (MU-MIMO mode value) to restrict a precoding matrix from being used as a second precoding matrix for each layer (restriction signal, [0062]); and

transmitting, to a transmitting device, 1st channel status information indicating a first precoding matrix and 2nd channel status information indicating a second precoding

matrix, the first precoding matrix and the second precoding matrix being selected (transceiver 12 receive restriction signal, [0062]), the first precoding matrix and the second precoding matrix selected by the receiving device based on the codebook restricting information (PMI values, [0061]), based on the codebook restricting information, from among precoding matrices that are not restricted from being used as the first precoding matrix or the second precoding matrix in a codebook (PMI values, [0061]).

Hammarwall discloses the claimed invention except explicitly teaches the terms of first and second information. However, it would have been obvious to one skilled in the art at the time the invention was made to utilize the teaching by Hammarwall to achieve the same expected results.

Re Claims 19 and 26, Hammarwall discloses the method of claim 18 and the device of claim 25, wherein the first information and the second information are provided in a bitmap format (bitmap-based signaling, [0010]).

Re Claims 20 and 27, Hammarwall discloses the method of claim 18 and the device of claim 25, wherein the use of second precoding matrices that make pairs with the first precoding matrix is restricted based on the first information and the use of first precoding matrices that make pairs with the second precoding matrix is restricted based on the second information (mode indicator, rank information, [0062], [0091]).

4. Claims 5, 7, 14, 16-17, 21, 28 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Hammarwall et al. (US 2011/0249713 A1) (Hammarwall herein after) in view of Jongren et al. (US 2011/0305263 A1) (Jongren herein after).

Re Claim 5, Hammarwall discloses the method of claim 1, except explicitly teaches wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

However, Jongren discloses a methods providing precoder feedback using multiple precoder indices wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other (polarization orthogonal, [0054]); and the first precoding matrix performs precoding on the first domain and the second domain (conversion precoder, [0059]), separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain (selection and adjustment precoders, [0059], phase adjustment).

Therefore, it would have been obvious at the time the invention was made to one of ordinary skill in the art to modify the system and method of Hammarwall, by making use of the technique taught by Jongren, in order to improve the closed loop precoder selection.

Both references are within the same field of digital communication, and in particular of MIMO system, the modification does not change a fundamental operating principle of Hammarwall, nor does Hammarwall teach away from the modification (Hammarwall merely discloses a preferred embodiment). The combination has a reasonable expectation of success in that the modifications can be made using conventional and well known engineering and/or programming techniques, the method and system taught by Jongren is not altered and continues to perform the same function as separately, and the resultant combination produces the highly predictable result of wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

Re Claim 7, the combined teachings disclose the method of claim 5, Jongren discloses wherein a number of the antenna pairs corresponds to 4 (NT antenna

elements and NT could be 4, [0054]).

Re Claim 14, Hammarwall discloses the device of claim 10, except explicitly teaches wherein the antenna array includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

However, Jongren discloses a methods providing precoder feedback using multiple precoder indices wherein the antenna array includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other (polarization orthogonal, [0054]); and the first precoding matrix performs precoding on the first domain and the second domain (conversion precoder, [0059]), separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain (selection and adjustment precoders, [0059], phase adjustment).

Therefore, it would have been obvious at the time the invention was made to one of ordinary skill in the art to modify the system and method of Hammarwall, by making

use of the technique taught by Jongren, in order to improve the closed loop precoder selection.

Both references are within the same field of digital communication, and in particular of MIMO system, the modification does not change a fundamental operating principle of Hammarwall, nor does Hammarwall teach away from the modification (Hammarwall merely discloses a preferred embodiment). The combination has a reasonable expectation of success in that the modifications can be made using conventional and well known engineering and/or programming techniques, the method and system taught by Jongren is not altered and continues to perform the same function as separately, and the resultant combination produces the highly predictable result of wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

Re Claim 16, the combined teachings disclose the device of claim 14, Jongren discloses wherein the first domain and the second domain intersect each other (polarization orthogonal, [0054]).

Re Claim 17, the combined teachings disclose the device of claim 14, Jongren discloses wherein a number of the antenna pairs corresponds to 4 (NT antenna elements and NT could be 4, [0054]).

Re Claims 21 and 28, Hammarwall discloses the method of claim 18 and the device of claim 25, except explicitly teaches wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

However, Jongren discloses a methods providing precoder feedback using multiple precoder indices wherein the antenna array includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other (polarization orthogonal, [0054]); and the first precoding matrix performs precoding on the first domain and the second domain (conversion precoder, [0059]), separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain (selection and adjustment precoders, [0059], phase adjustment).

Therefore, it would have been obvious at the time the invention was made to one of ordinary skill in the art to modify the system and method of Hammarwall, by making use of the technique taught by Jongren, in order to improve the closed loop precoder selection.

Both references are within the same field of digital communication, and in particular of MIMO system, the modification does not change a fundamental operating principle of Hammarwall, nor does Hammarwall teach away from the modification (Hammarwall merely discloses a preferred embodiment). The combination has a reasonable expectation of success in that the modifications can be made using conventional and well known engineering and/or programming techniques, the method and system taught by Jongren is not altered and continues to perform the same function as separately, and the resultant combination produces the highly predictable result of wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

Allowable Subject Matter

5. Claims 6, 8-9, 15, 22-24, 29-31 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to KENNETH LAM whose telephone number is (571)270-1862. The examiner can normally be reached on Mon - Fri 8:00 am - 4:30 pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Shuwang Liu can be reached on (571) 272-3036. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/KENNETH LAM/
Primary Examiner, Art Unit 2631

Notice of References Cited	Application/Control No. 13/807,706	Applicant(s)/Patent Under Reexamination PARK, KYOUNGMIN	
	Examiner KENNETH LAM	Art Unit 2631	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2011/0249713	10-2011	Hammarwall et al.	375/220
*	B	US-2011/0305263	12-2011	J+e et al.	375/219
*	C	US-2011/0034192	02-2011	Lim et al.	455/501
*	D	US-2012/0003945	01-2012	Liu et al.	455/115.1
*	E	US-2010/0322176	12-2010	Chen et al.	370/329
*	F	US-2011/0032839	02-2011	Chen et al.	370/252
*	G	US-2011/0274188	11-2011	Sayana et al.	375/260
*	H	US-2012/0127948	05-2012	Chung et al.	370/329
*	I	US-2011/0206024	08-2011	LEE et al.	370/338
*	J	US-2011/0268068	11-2011	Jian et al.	370/329
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13807706	PARK, KYOUNGMIN
	Examiner	Art Unit
	KENNETH LAM	2631

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	05/28/2014								
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	27	✓								
	28	✓								
	29	O								
	30	O								
	31	O								

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	42	((Kyoungmin) near2 (Park)).INV.	US-PGPUB; USPAT	AND	ON	2014/05/23 09:08
S2	611	second with prec?d$4 with codebook	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/23 09:08
S3	4	S1 S2	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/23 09:08
S4	2	"20120275314"	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/23 10:28
S5	536	restrict$4 with codebook	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/23 10:29
S6	11727	prec?d$4 near3 matrix	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/23 10:29
S7	265	S5 S6	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/23 10:29
S8	338	CSI and (first near2 prec?d$4) and (second near2 prec?d$4)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/23 10:30
S10	5	"12194640"	US-PGPUB; USPAT; FPRS; EPO; JPO;	AND	ON	2014/05/23 12:46

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S11	537	restrict$4 with codebook	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:15
S12	11757	prec?d$4 near3 matrix	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:15
S13	266	S11 S12	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:15
S14	339	CSI and (first near2 prec?d$4) and (second near2 prec?d$4)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:15
S15	37	S13 S14	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:15
S16	18774	((H04B7/0639 OR H04B7/0456 OR H04B7/0469 OR H04B7/0634 OR H04B7/0413 OR H04B7/0452 OR H04B7/0626).CPC.)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:20
S17	234	S11 S16	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:21
S18	33	S14 S17	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:21
S19	70	restrict$4 same prec?d$4 same layer same codebook	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 11:00
S20	46	S16 S19	US-PGPUB; USPAT; FPRS; EPO; JPO;	AND	ON	2014/05/27 11:00

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S21	339	CSI and (first near2 prec?d$4) and (second near2 prec?d$4)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:05
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S23	12	S21 S22	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:06
S24	57	restrict$4 same codebook same first same second same prec?d$4	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:07
S25	16	S21 S24	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:07
S26	8541	(first near2 prec?d$4) and (second near2 prec?d$4)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:20
S27	12	S21 S22 S26	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:20
S28	280	(first near2 prec?der) and (second near2 prec?der)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:21
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S30	32	("20030143961" | "20040052314" | "20040192398" | "20050124393" | "20050250532" | "20060067277" | "20060292990" | "20070093281" | "20070211813" | "20070232370" |	US-PGPUB; USPAT; USOCR	AND	ON	2014/05/27 14:24

		"20070255558" | "20080001915" | "20080080449" | "20080165876" | "20080274753" | "20080298482" | "20090122884" | "20100023898" | "20100034312" | "20100035627" | "20100046650" | "20100157924" | "20100208838" | "20100220801" | "20100322176" | "20110051834" | "20110080969" | "20110216840" | "7649831" | "7822140" | "7885211" | "8284849").PN. OR ("8509338").URPN.				
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S34	20	S28 S33	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:38
S35	114	rank with restrict$4 same codebook	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:55
S36	16	S21 S35	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:55
S37	2	"13104644"	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:56
S38	1239	restrict$4 with rank	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 15:00
S39	17	S28 S38	US-PGPUB;	AND	ON	2014/05/27 15:01

			USPAT; FPRS; EPO; JPO; DERWENT			
S40	3681	channel near2 status near2 information	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 15:10
S41	9	S33 S38 S40	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 15:10
S42	17	S33 S40	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 15:12
S43	3	S22 S40	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 15:18
S44	3	(("20100048233") or ("20110116563") or ("20090257383")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/05/27 17:19
S45	180	first near2 prec?d$4 with gain	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/28 09:21
S46	613	second near2 prec?d$4 with phase	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/28 09:21
S47	5	S45 S46	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/28 09:21
S48	857	(prec?d$4 with gain) and (prec?d$4 with phase)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/28 09:22
S49	537	restrict$4 with codebook	US-PGPUB; USPAT; FPRS;	AND	ON	2014/05/28 09:22

			EPO; JPO; DERWENT			
S50	37	S48 S49	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/28 09:22
S51	15	pmi and csi and S50	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/28 09:23
S52	66	pmi and csi and S48	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/28 09:27

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13/807,706	12/28/2012	375	2631	P5158US00

APPLICANTS

INVENTORS

Kyoungmin Park, Seoul, KOREA, REPUBLIC OF;

**** CONTINUING DATA ***************************

This application is a 371 of PCT/KR2011/004835 07/01/2011

**** FOREIGN APPLICATIONS ***************************

REPUBLIC OF KOREA 10-2010-0064573 07/05/2010

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01/23/2013

Foreign Priority claimed	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
☑ Yes ☐ No	KOREA, REPUBLIC OF	10	31	4

35 USC 119(a-d) conditions met ☑ Yes ☐ No ☐ Met after Allowance

Verified and Acknowledged /KENNETH T LAM/ Examiner's Signature _____ Initials

ADDRESS

H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191
UNITED STATES

TITLE

TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2012-12-28
First Named Inventor	Kyoungmin PARK
Art Unit	
Examiner Name	
Attorney Docket Number	P5158US00

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20100048233		2010-02-25	KIM et al.	
	2	20110116563		2011-05-19	VITTHALADEVUNI et al.	
	3	20090257383		2009-10-15	LEE et al.	Corresponds to WO 2009-125956

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FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	2009-125956	WO		2009-10-15	LG ELECTRONICS INC. et al.	Corresponds to US 20090257383	☐

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /K.L./

Receipt date: 12/28/2012	Application Number	13807706 - GAU: 2631
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99**)	Filing Date	2012-12-28
	First Named Inventor	Kyoungmin PARK
	Art Unit	
	Examiner Name	
	Attorney Docket Number	P5158US00

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NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	International Search Report dated December 28, 2011 issued for related International Application No. PCT/ KR2011/004835.	☐

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EXAMINER SIGNATURE

Examiner Signature	/Kenneth Lam/	Date Considered	05/28/2014

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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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Receipt date: 12/28/2012	Application Number	13807706 - GAU: 2631
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99**)	Filing Date	2012-12-28
	First Named Inventor	Kyoungmin PARK
	Art Unit	
	Examiner Name	
	Attorney Docket Number	P5158US00

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/hae-chan park/	Date (YYYY-MM-DD)	2012-12-28
Name/Print	Hae-Chan Park	Registration Number	50114

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13807706	PARK, KYOUNGMIN
	Examiner	Art Unit
	KENNETH LAM	2631

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES		
Search Notes	Date	Examiner
inventor search	5/28/2014	KL
EAST search	5/28/2014	KL
CPC search	5/28/2014	KL

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

	/KENNETH LAM/ Primary Examiner.Art Unit 2631

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:	Docket No.: P5158US00
Kyoungmin PARK	
Serial No.: 13/807,706	Group Art Unit: 2631
Confirmation No.: 9187	
Filed: December 28, 2012	Examiner: LAM, KENNETH T

For: **TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH**

Mail Stop: Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REPLY UNDER 37 C.F.R. § 1.111

Dear Madame:

In response to the Non-Final Office Action dated June 2, 2014 ("Office Action"), Applicant respectfully requests reconsideration of the Application in view of the following Amendments and Remarks.

Amendments to the Claims begin on page 2.

Remarks begin on page 13.

No extensions of time are required at this time. If extensions of time are necessary to prevent abandonment of this Application, then they are petitioned for under 37 C.F.R. § 1.136(a). No fees for net addition of claims are required at this time. Any fees required for extensions of time or for the net addition of claims may be charged to our Deposit Account No. 50-3698.

AMENDMENTS TO THE CLAIMS

Please **AMEND** claims 1-6, 10-15, 18-22, and 25-29 as shown below.

This claim list replaces all prior claim lists in the Application.

1. (Currently Amended) A communication method of a transmitting device including a first precoder and a second precoder, the method comprising:

determining ~~first information~~a first bit sequence to restrict [[a]]at least one precoding matrix from a first precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, and the at least one precoding matrix of the first precoding matrix group being restricted from being used as a ~~first~~ precoding matrix of the first precoder;

~~, and second information~~determining a second bit sequence to restrict [[a]]at least one precoding matrix from a second precoding matrix group, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the second precoding matrix group being restricted from being used as ~~the second~~a precoding matrix of [[a]]the second precoder ~~in a corresponding codebook with respect to each layer~~; and

transmitting, to a receiving device, codebook restricting information including at least one of ~~the determined first information and second information~~the first bit sequence and the second bit sequence.

2. (Currently Amended) The method of claim 1, further comprising:

receiving, from the receiving device, 1st channel status information indicating ~~a first~~the

precoding matrix of the first precoder and 2nd channel status information indicating ~~a second~~the precoding matrix of the second precoder, the ~~first~~ precoding matrix of the first precoder and the ~~second~~ precoding matrix of the second precoder selected by the receiving device based on the ~~codebook restricting information~~first bit sequence and the second bit sequence, respectively; and

precoding data symbols through the first precoder and the second precoder using the ~~first~~ precoding matrix corresponding to the received 1st channel status information and the ~~second~~ precoding matrix corresponding to the ~~second~~2nd status information, and transmitting the precoded data symbols.

3. (Currently Amended) The method of claim 1, wherein ~~the first information and the second information are provided in a bitmap format~~the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

4. (Currently Amended) The method of claim 1, wherein the use of ~~second~~ precoding matrices for the second precoder that make pairs with ~~the first~~restricted precoding ~~matrix~~matrices of the first matrix group is restricted based on the first ~~information~~bit sequence, and the use of ~~first~~ precoding matrices for the first precoder that make pairs with ~~the second~~restricted precoding ~~matrix~~matrices of the second matrix group is restricted based on the second bit sequence.

5. (Currently Amended) The method of claim 1, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the ~~first~~ precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the ~~second~~ precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

6. (Currently Amended) The method of claim 5, wherein the ~~first~~ precoding matrix of the first precoder corresponds to W1 in the following Equation, and the ~~second~~ precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

7. (Original) The method of claim 5, wherein a number of the antenna pairs corresponds to 4.

8. (Original) The method of claim 2, wherein, in receiving of the 1st channel status information and the 2nd channel status information, a period of receiving the 1st channel status information and a period of receiving the 2nd channel status information are different from each other.

9. (Original) The method of claim 8, wherein the period of receiving the 1st channel status information is longer than the period of receiving the 2nd channel status information.

10. (Currently Amended) A transmitting device, the device comprising:

a layer mapper to map a codeword to a layer;

a precoder ~~including a first precoder and a second precoder that performs precoding on~~configured to precode a data symbol corresponding to the codeword mapped to the layer by the layer mapper, the precoder precoding the data symbol using a ~~first~~ precoding matrix of a first precoder and a ~~second~~ precoding matrix of a second precoder selected from [[a]] corresponding codebooks; and

an antenna array to transmit signals output from the precoder, the signals including at least one of a first bit sequence and a second bit sequence,

wherein ~~the codeword includes at least one of first information~~the first bit sequence restricts ~~to restrict a~~at least one precoding matrix from a first precoding matrix group, the at least one precoding matrix of the first precoding matrix group being restricted from being used as the ~~first~~ precoding matrix of the first precoder, [[and]]

~~second information~~wherein the second bit sequence restricts ~~to restrict a~~at least one precoding matrix from a second precoding matrix group, the at least one precoding matrix of the second precoding matrix group being restricted from being used as the ~~second~~ precoding matrix of the second precoder ~~in the corresponding codebook with respect to each layer~~, and

wherein each bit of the first bit sequence corresponds to one precoding matrix of the first precoding matrix group, respectively, and each bit of the second bit sequence corresponds to one precoding matrix of the second precoding matrix group, respectively.

11. (Currently Amended) The device of claim 10, wherein the antenna array receives

1st channel status information indicating ~~a first~~ the precoding matrix of the first precoder and 2nd channel status information indicating ~~a second~~the precoding matrix of the second precoder; and

the first precoder and the second precoder perform precoding on data symbols using the ~~first~~ precoding matrix corresponding to the received 1st channel status information and the ~~second~~ precoding matrix corresponding to the received 2nd channel status information, respectively.

12. (Currently Amended) The device of claim 10, wherein ~~the first information and the second information are provided in a bitmap format~~the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

13. (Currently Amended) The device of claim 10, wherein the use of ~~second~~ precoding matrices for the second precoder that make pairs with ~~the first~~restricted precoding ~~matrix~~matrices of the first matrix group is restricted based on the first ~~information~~bit sequence, and the use of ~~first~~ precoding matrices for the first precoder that make pairs with ~~the second~~restricted precoding ~~matrix~~matrices of the second matrix group is restricted based on the second ~~information~~bit sequence.

14. (Currently Amended) The device of claim 10, wherein the antenna array includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the ~~first~~ precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the ~~second~~ precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the

first domain and the second domain.

15. (Currently Amended) The device of claim 14, wherein the ~~first~~ precoding matrix of the first precoder corresponds to W1 in the following Equation, and the ~~second~~ precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

16. (Original) The device of claim 14, wherein the first domain and the second domain intersect each other.

17. (Original) The device of claim 14, wherein a number of the antenna pairs corresponds to 4.

18. (Currently Amended) A communication method of a receiving device in a wireless communication system, the method comprising:

receiving codebook restricting information including at least one of ~~first informationa~~ first bit sequence to restrict [[a]]at least one precoding matrix from a first precoding matrix group and

a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, the at least one precoding matrix of the first precoding matrix group being restricted from being used as a ~~first~~ precoding matrix of a first precoder, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and ~~second information to restrict a precoding matrix~~the at least one precoding matrix of the second precoding matrix group being restricted from being used as a ~~second~~ precoding matrix of a second precoder ~~for each layer~~; and

transmitting, to a transmitting device, 1st channel status information indicating ~~a first~~the precoding matrix of the first precoder and 2nd channel status information indicating ~~a second~~the precoding matrix of the second precoder, the ~~first~~ precoding matrix of the first precoder and the ~~second~~ precoding matrix of the second precoder, the precoding matrix of the first precoder and the precoding matrix of the second precoder being selected, based on the codebook restricting information, from among precoding matrices that are not restricted ~~from being used as the first precoding matrix or the second precoding matrix in a codebook~~.

19. (Currently Amended) The method of claim 18, wherein ~~the first information and the second information are provided in a bitmap format~~the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

20. (Currently Amended) The method of claim 18, wherein the use of ~~second~~ precoding matrices for the second precoder that make pairs with ~~the first~~restricted precoding ~~matrix~~matrices of the first matrix group is restricted based on the first ~~information~~bit sequence, and the use of ~~first~~ precoding matrices for the first precoder that make pairs with ~~the second~~restricted precoding ~~matrix~~matrices of the second matrix group is restricted based on the

second ~~information~~bit sequence.

21. (Currently Amended) The method of claim 18, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the ~~first~~ precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the ~~second~~ precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

22. (Currently Amended) The method of claim 21, wherein the ~~first~~ precoding matrix of the first precoder corresponds to W1 in the following Equation and the ~~second~~ precoding matrix of the second precoder corresponds to [[W1]]W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

23. (Original) The method of claim 18, wherein, in transmitting, a period of transmitting the 1st channel status information and a period of transmitting the 2nd channel status

information are different from each other.

24. (Original) The method of claim 23, wherein the period of transmitting the 1st channel status information is longer than the period of transmitting the 2nd channel status information.

25. (Currently Amended) A receiving device in a wireless communication system, the receiving device comprising:

an antenna array to receive, as codebook restricting information, at least one of ~~first information~~a first bit sequence to restrict [[a]]at least one precoding matrix from a first precoding matrix group and a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, the at least one precoding matrix of the first precoding matrix group being restricted from being used as a ~~first~~ precoding matrix of a first precoder, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and ~~first information to restrict a precoding matrix~~the at least one precoding matrix of the second precoding matrix group being restricted from being used as a ~~second~~ precoding matrix of a second precoder ~~with respect to each layer~~; and

a channel information feedback device to transmit, to a transmitting device, 1st channel status information indicating ~~a first~~the precoding matrix of the first precoder and 2nd channel status information indicating ~~a second~~the precoding matrix of the second precoder, the ~~first~~ precoding matrix of the first precoder and the ~~second~~ precoding matrix of the second precoder being selected, based on the codebook restricting information, from among precoding matrices that are not restricted ~~from being used as the first precoding matrix of the second precoding~~

~~matrix in a codebook~~.

26. (Currently Amended) The device of claim 25, wherein the ~~first information and the second information are provided in a bitmap format~~the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

27. (Currently Amended) The device of claim 25, wherein the use of ~~second~~ precoding matrices for the second precoder that make pairs with ~~the first~~restricted precoding ~~matrix~~matrices of the first matrix group is restricted based on the first ~~information~~bit sequence, and the use of ~~first~~ precoding matrices for the second precoder that make pairs with ~~the second~~restricted precoding ~~matrix~~matrices of the second matrix group is restricted based on the second ~~information~~bit sequence.

28. (Currently Amended) The device of claim 25, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the ~~first~~ precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the ~~second~~ precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

29. (Currently Amended) The device of claim 28, wherein the ~~first~~ precoding matrix of the first precoder corresponds to W1 in the following Equation, and the ~~second~~ precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

30. (Original) The device of claim 25, wherein a period of transmitting the 1st channel status information and a period of transmitting the 2nd channel status information are different from each other.

31. (Original) The device of claim 30, wherein the period of transmitting the 1st channel status information is longer than the period of transmitting the 2nd channel status information.

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REMARKS

Claims 1-6, 10-15, 18-22, and 25-29 have been amended. Accordingly, claims 1-31 are currently pending in the Application, of which claims 1, 10, 18, and 25 are independent. Applicant appreciates the indication that claims 6, 8, 9, 15, 22-24, and 29-31 contain allowable subject matter.

Applicant respectfully submits that the above amendments do not add new matter to the Application and are fully supported by the specification. Support for the amendments and added claims may be found at least at paragraphs [0034]-[0039], [0043], [0078]-[0094], and [0102]-[0103] of the specification (*See* substitute specification for paragraph numbers).

In view of the above amendments and the following Remarks, Applicant respectfully requests reconsideration and timely withdrawal of the pending objections and rejections for the reasons discussed below.

Rejections under 35 U.S.C. § 103

To establish an obviousness rejection under 35 U.S.C. § 103(a), four factual inquiries must be examined. The four factual inquiries include (a) determining the scope and contents of the prior art; (b) ascertaining the differences between the prior art and the claims in issue; (c) resolving the level of ordinary skill in the pertinent art; and (d) evaluating evidence of secondary consideration. *Graham v. John Deere*, 383 U.S. 1, 17-18 (1966).

In view of these four factors, the analysis supporting a rejection under 35 U.S.C. § 103(a) should be made explicit, and should "identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the [prior art] elements" in the manner claimed. *KSR Int'l. Co. v. Teleflex, Inc.*, 127 S. Ct. 1727, 82 USPQ2d 1385, 1396 (2007). The Federal Circuit requires that "rejections on obviousness cannot be sustained with mere conclusory statements; instead, there must be some articulated reasoning with some rational

underpinning to support the legal conclusion of obviousness." *In re Kahn*, 441 F.3d 977, 988, 78 USPQ2d 1329, 1336 (Fed. Cir. 2006).

Finally, even if the prior art may be combined, there must be a reasonable expectation of success, and the reference or references, when combined, must disclose or suggest every claimed feature. *See In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

Claims 1-4, 10-13, 18-20, and 25-27 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over U.S. Patent Application Publication No. 2011/0249713, applied for by Hammarwall *et al*. ("Hammarwall"). Without conceding to the correctness of the assertions included in the Office Action, claim 1 has been amended for further clarification and to advance prosecution.

Amended claim 1 recites, *inter alia*:

> determining a first bit sequence to restrict at least one precoding matrix from a first precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, and the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of the first precoder;
> determining a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the second precoding matrix group being restricted from being used as a precoding matrix of the second precoder;

In the Office Action, the Examiner alleges that Hammarwall's paragraphs [0058], [0062], and [0091] disclose features of claim 1. However, the rejection of claim 1 has been rendered moot in view of amended claim 1.

Hammarwall does not disclose or suggest two bit sequences. Although Hammarwall discloses restrict a ***precoder*** selection (*See e.g.*, Hammarwall paragraph [0062]), Hammarwall

does not disclose or suggest restriction of a ***precoding matrix***. Specifically, Hammarwall's paragraph [0062] discloses "[t]o constrain or otherwise restrict the ***precoder*** selections made by the transceiver 12, the transceiver 10 transmits restriction signaling 48." Furthermore, Hammarwall does not disclose or suggest a restriction of "at least one precoding matrix from a first precoding matrix group" and a restriction of "at least one precoding matrix from a second precoding matrix group" as recited in amended claim 1. Hammarwall also fails to disclose or suggest at least "each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively" and "each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively" as recited in amended claim 1.

Thus, Hammarwall does not disclose or suggest each and every feature of amended claim 1.

Amended claims 10, 18, and 25 includes features similar to those discussed above with respect to amended claim 1, and therefore, are patentable for at least similar reasons as those discussed above with respect to amended claim 1.

Accordingly, Applicant respectfully requests withdrawal of the 35 U.S.C. § 103(a) rejection of claims 1, 10, 18, and 25. Claims 2-4, 11-13, 19, 20, 26, and 27 depend from claims 1, 10, 18 or 25 and are allowable at least for this reason. Since none of the alleged prior art of record, whether taken alone or in any combination, discloses or suggests all the features of the claimed subject matter, Applicant submits that independent claims 1, 10, 18, and 25, and all the claims that depend therefrom, are allowable.

Claims 5, 7, 14, 16, 17, 21, and 28 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Hammarwall in view of U.S. Patent Application Publication No. 2011/0305263, applied for by Jongren, *et al*. ("Jongren").

Applicant respectfully submits that claims 1, 10, 18, and 25 are allowable over Hammarwall, and Jongren fails to cure the deficiencies of Hammarwall noted above with regard to claim 1. Hence, claims 5, 7, 14, 16, 17, 21, and 28 are allowable at least because they depend from an allowable base claim.

Allowable Subject Matter

Applicant appreciates the indication that claims 6, 8, 9, 15, 22-24, and 29-31 contain allowable subject matter. Applicant respectfully submits that claims 1, 10, 18, and 25 are allowable over the cited references and claims 6, 8, 9, 15, 22-24, and 29-31 depend therefrom are allowable at least because they depend from an allowable base claim.

Accordingly, Applicant submits that claims 6, 8, 9, 15, 22-24, and 29-31 are in condition for allowance.

CONCLUSION

A full and complete response has been made to the pending Office Action, and all of the stated objections and grounds for rejection have been overcome or rendered moot. Accordingly, all pending claims are allowable, and the Application is in condition for allowance.

The Examiner is invited to contact Applicant's undersigned representative at the number below if it would expedite prosecution. Prompt and favorable consideration of this Reply is respectfully requested.

Respectfully submitted,

/dongil moon/

Dongil Moon
Reg. No. L0830

Date: September 2, 2014

CUSTOMER NUMBER: 58027
H.C. Park & Associates, PLC
1894 Preston White Drive
Reston, VA 20191
Tel: 703-288-5105
Fax: 703-288-5139
HCP/DM/dea

Electronic Acknowledgement Receipt

EFS ID:	20024724
Application Number:	13807706
International Application Number:	
Confirmation Number:	9187
Title of Invention:	TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH
First Named Inventor/Applicant Name:	Kyoungmin Park
Customer Number:	58027
Filer:	Hae-Chan Park/Nathan Cristler
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		p5158us00_for_filing.pdf	126127 7123e8cc7e1f6f7965f0c4dbb81e9f6e4427d5ba	yes	17

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	12
	Applicant Arguments/Remarks Made in an Amendment	13	17
Warnings:			
Information:			
	Total Files Size (in bytes):	126127	

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

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New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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13/807,706	12/28/2012	Kyoungmin Park	P5158US00	9187

58027 7590 09/17/2014

H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191

EXAMINER	
LAM, KENNETH T	

ART UNIT	PAPER NUMBER
2631	

NOTIFICATION DATE	DELIVERY MODE
09/17/2014	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

PATENT@PARK-LAW.COM

Office Action Summary	Application No. 13/807,706	Applicant(s) PARK, KYOUNGMIN	
	Examiner KENNETH LAM	Art Unit 2631	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *09/02/2014*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1-31* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-5,7,10-14,16-21 and 25-28* is/are rejected.

8)☒ Claim(s) *6, 8, 9, 15, 22-24, 29-31* is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

DETAILED ACTION

1. The present application is being examined under the pre-AIA first to invent provisions.

2. This office action is in response to the amendment filed on 09/02/2014. Claims 1-31 are pending in this application and have been considered below.

Response to Amendment

3. Applicant's arguments with respect to claims 1-31 have been considered but are moot in view of the new ground(s) of rejection because of the amendment changes the scope of the invention.

Claim Rejections - 35 USC § 103

4. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under pre-AIA 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.

2. Ascertaining the differences between the prior art and the claims at issue.

3. Resolving the level of ordinary skill in the pertinent art.

4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

5. Claims 1-4, 10-13, 18-20, 25-27 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Hammarwall et al. (US 2011/0249713 A1) (Hammarwall herein after) in view of Lim et al. (US 2011/0034192 A1) (Lim herein after).

Re Claim 1, Hammarwall discloses a communication method of a transmitting device including a first precoder and a second precoder, the method comprising:

determining a first bit sequence (restriction signal M-length bit mark and one or more binary values, [0071]) to restrict at least one precoding matrix from a first precoding matrix group, (mode indicator, [0062], conversion precoder, [0058]), each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group (subset could be single precoder, [0071]), respectively, and the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of the first precoder (mode indicator, rank information, [0062], [0091], restrict precoder selection, [0074]);

determining a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group (Mode 2, [0069]), each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the second precoding matrix

group being restricted from being used as a precoding matrix of the second precoder (mode indicator, rank information, [0062], [0091]); and

transmitting, to a receiving device, codebook restricting information (restriction signal, [0062]) including at least one of first bit sequence and the second bit sequence.

Hammarwall discloses the claimed invention except explicitly teaches the precoding matrix. However, Lim discloses used precoding matrix cause strong affects to a neighbor cell and embodiments to reduece the flashlight effect ([0078]). Therefore, it would have been obvious to one skilled in the art at the time the invention was made to utilize the teaching by Lim with the invention taught by Hammarwall to achieve the same expected results of restricting at least one precoding matrix from a first precoding matrix group.

Re Claim 2, Hammarwall discloses the method of claim 1, further comprising:

receiving, from the receiving device, 1st channel status information indicating the precoding matrix of the first precoder and 2nd channel status information indicating the precoding matrix of the second precoder (transceiver 12 receive restriction signal, [0062]), the precoding matrix or the first precoder and the precoding matrix of the second precoder selected by the receiving device based on the first bit sequence and the second bit sequence, respectively (PMI values, [0061]); and

precoding data symbols through the first precoder and the second precoder using the precoding matrix corresponding to the received 1st channel status information and the precoding matrix corresponding to the 2nd status information (conversion

precoder, tuning precoder, [0058], CSI, [0113]-[0114]), and transmitting the precoded data symbols.

Re Claim 3, Hammarwall discloses the method of claim 1, wherein the first matrix group includes N precoding matrices (precoding matrices utilized in precoder, [0059]), and the first bit sequence is an N-bit sequence, where N is an integer (bitmap-based signaling, [0010], restriction signal M-length bit mark and one or more binary values, [0071]).

Re Claim 4, Hammarwall discloses the method of claim 1, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence (mode indicator, rank information, [0062], [0091], restriction signal M-length bit mark and one or more binary values, [0071]).

Re Claim 10, Hammarwall discloses a transmitting device, the device comprising:

a layer mapper to map a codeword to a layer (layer processing circuitry, [0092]);

a precoder (tuning precoder, [0058], mode indicator, [0062], conversion precoder, [0058]) configured to precode a data symbol corresponding to the codeword mapped to the layer by the layer mapper, the precoder precoding the data symbol using

a precoding matrix of a first precoder and a precoding matrix of a second precoder selected from corresponding codebooks (PMI values, [0061]); and

an antenna array to transmit signals output from the precoder, the signals including at least one of a first bit sequence and a second bit sequence (restriction signal M-length bit mark and one or more binary values, [0071]),

wherein the first bit sequence (restriction signal M-length bit mark and one or more binary values, [0071]) restricts at least one precoding matrix from a first precoding matrix group, (mode indicator, [0062], conversion precoder, [0058]), the at least one precoding matrix of the first precoding matrix group being restricted from being used as the precoding matrix of the first precoder (mode indicator, rank information, [0062], [0091], restrict precoder selection, [0074]);

wherein the second bit sequence restricts at least one precoding matrix from a second precoding matrix group (Mode 2, [0069]), the at least one precoding matrix of the second precoding matrix group being restricted from being used as the precoding matrix of the second precoder (mode indicator, rank information, [0062], [0091]), and

wherein each bit of the first bit sequence corresponds to one precoding matrix of the first precoding matrix group, respectively, and each bit of the second bit sequence corresponds to one precoding matrix of the second precoding matrix group, respectively (mode indicator, rank information, [0062], [0091], restrict precoder selection, [0074]).

Hammarwall discloses the claimed invention except explicitly teaches the precoding matrix. However, Lim discloses used precoding matrix cause strong affects to a neighbor cell and embodiments to reduece the flashlight effect ([0078]). Therefore,

it would have been obvious to one skilled in the art at the time the invention was made to utilize the teaching by Lim with the invention taught by Hammarwall to achieve the same expected results of restricting at least one precoding matrix from a first precoding matrix group.

Re Claim 11, Hammarwall discloses the device of claim 10, wherein the antenna array receives 1st channel status information indicating the precoding matrix of the first precoder and 2nd channel status information indicating the precoding matrix of the second precoder (transceiver 12 receive restriction signal, [0062]); and

the first precoder and the second precoder perform precoding on data symbols using the precoding matrix corresponding to the received 1st channel status information and the precoding matrix corresponding to the received 2nd channel status information (conversion precoder, tuning precoder, [0058], CSI, [0113]-[0114]), respectively.

Re Claim 12, Hammarwall discloses the device of claim 10, wherein the first matrix group includes N precoding matrices (precoding matrices utilized in precoder, [0059]), and the first bit sequence is an N-bit sequence, where N is an integer (bitmap-based signaling, [0010], restriction signal M-length bit mark and one or more binary values, [0071]).

Re Claim 13, Hammarwall discloses the device of claim 10, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding

matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence (mode indicator, rank information, [0062], [0091], restriction signal M-length bit mark and one or more binary values, [0071]).

Re Claims 18 and 25, Hammarwall discloses a communication method of a receiving device in a wireless communication system and a receiving device in a wireless communication system, the method and the device comprising:

receiving codebook restricting information (restriction signal, [0062]) including at least one of a first bit sequence to restrict at least one precoding matrix from a first precoding matrix group and a second bit sequence (Mode 2, [0069]) to restrict at least one precoding matrix from a second precoding matrix group (restriction signal M-length bit mark and one or more binary values, [0071]), each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of a first precoder, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the second precoding matrix group being restrcited from being used as a precoding matrix of a second precoder ((mode indicator, [0062], conversion precoder, [0058])); and

transmitting, to a transmitting device, 1st channel status information indicating the precoding matrix of the first precoder and 2nd channel status information indicating the precoding matrix of the second precoder (transceiver 12 receive restriction signal, [0062]), the precoding matrix of the first precoder and the precoding matrix of the second precoder, the precoding matrix of the first precoder and the precoding matrix of the second precoder being selected, based on the codebook restricting information (mode indicator, rank information, [0062], [0091]), from among precoding matrices that are not restricted (conversion precoder, tuning precoder, [0058], CSI, [0113]-[0114]).

Hammarwall discloses the claimed invention except explicitly teaches the precoding matrix. However, Lim discloses used precoding matrix cause strong affects to a neighbor cell and embodiments to reduece the flashlight effect ([0078]). Therefore, it would have been obvious to one skilled in the art at the time the invention was made to utilize the teaching by Lim with the invention taught by Hammarwall to achieve the same expected results of restricting at least one precoding matrix from a first precoding matrix group.

Re Claims 19 and 26, the combined teachings disclose the method of claim 18 and the device of claim 25, Hammarwall discloses wherein the first matrix group includes N precoding matrices (precoding matrices utilized in precoder, [0059]), and the first bit sequence is an N-bit sequence, where N is an integer (bitmap-based signaling, [0010], restriction signal M-length bit mark and one or more binary values, [0071]).

Re Claims 20 and 27, the combined teachings disclose the method of claim 18 and the device of claim 25, Hammarwall discloses wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence (mode indicator, rank information, [0062], [0091], restriction signal M-length bit mark and one or more binary values, [0071]).

6. Claims 5, 7, 14, 16-17, 21, 28 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Hammarwall et al. (US 2011/0249713 A1) (Hammarwall herein after) and Lim et al. (US 2011/0034192 A1) (Lim herein after), further in view of Jongren et al. (US 2011/0305263 A1) (Jongren herein after).

Re Claim 5, the combined teachings disclose the method of claim 1, except explicitly teaches wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

However, Jongren discloses a methods providing precoder feedback using multiple precoder indices wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other (polarization orthogonal, [0054]); and the first precoding matrix performs precoding on the first domain and the second domain (conversion precoder, [0059]), separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain (selection and adjustment precoders, [0059], phase adjustment).

Therefore, it would have been obvious at the time the invention was made to one of ordinary skill in the art to modify the system and method of Hammarwall, by making use of the technique taught by Jongren, in order to improve the closed loop precoder selection.

Both references are within the same field of digital communication, and in particular of MIMO system, the modification does not change a fundamental operating principle of Hammarwall, nor does Hammarwall teach away from the modification (Hammarwall merely discloses a preferred embodiment). The combination has a reasonable expectation of success in that the modifications can be made using conventional and well known engineering and/or programming techniques, the method and system taught by Jongren is not altered and continues to perform the same function as separately, and the resultant combination produces the highly predictable result of wherein the transmitting device includes at least one antenna pair in which a first

domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

Re Claim 7, the combined teachings disclose the method of claim 5, Jongren discloses wherein a number of the antenna pairs corresponds to 4 (NT antenna elements and NT could be 4, [0054]).

Re Claim 14, the combined teachings disclose the device of claim 10, except explicitly teaches wherein the antenna array includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

However, Jongren discloses a methods providing precoder feedback using multiple precoder indices wherein the antenna array includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a

second domain including at least one antenna polarized in another direction intersect each other (polarization orthogonal, [0054]); and the precoding matrix of the first precoder performs precoding on the first domain and the second domain (conversion precoder, [0059]), separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain (selection and adjustment precoders, [0059], phase adjustment).

Therefore, it would have been obvious at the time the invention was made to one of ordinary skill in the art to modify the system and method of Hammarwall, by making use of the technique taught by Jongren, in order to improve the closed loop precoder selection.

Both references are within the same field of digital communication, and in particular of MIMO system, the modification does not change a fundamental operating principle of Hammarwall, nor does Hammarwall teach away from the modification (Hammarwall merely discloses a preferred embodiment). The combination has a reasonable expectation of success in that the modifications can be made using conventional and well known engineering and/or programming techniques, the method and system taught by Jongren is not altered and continues to perform the same function as separately, and the resultant combination produces the highly predictable result of wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

Re Claim 16, the combined teachings disclose the device of claim 14, Jongren discloses wherein the first domain and the second domain intersect each other (polarization orthogonal, [0054]).

Re Claim 17, the combined teachings disclose the device of claim 14, Jongren discloses wherein a number of the antenna pairs corresponds to 4 (NT antenna elements and NT could be 4, [0054]).

Re Claims 21 and 28, the combined teachings disclose the method of claim 18 and the device of claim 25, except explicitly teaches wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

However, Jongren discloses a methods providing precoder feedback using multiple precoder indices wherein the antenna array includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other (polarization orthogonal, [0054]); and the precoding matrix of the first precoder performs precoding on the first domain and the second domain (conversion precoder, [0059]), separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain (selection and adjustment precoders, [0059], phase adjustment).

Therefore, it would have been obvious at the time the invention was made to one of ordinary skill in the art to modify the system and method of Hammarwall, by making use of the technique taught by Jongren, in order to improve the closed loop precoder selection.

Both references are within the same field of digital communication, and in particular of MIMO system, the modification does not change a fundamental operating principle of Hammarwall, nor does Hammarwall teach away from the modification (Hammarwall merely discloses a preferred embodiment). The combination has a reasonable expectation of success in that the modifications can be made using conventional and well known engineering and/or programming techniques, the method and system taught by Jongren is not altered and continues to perform the same function as separately, and the resultant combination produces the highly predictable result of

wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

Allowable Subject Matter

7. Claims 6, 8-9, 15, 22-24, 29-31 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Conclusion

8. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the

shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to KENNETH LAM whose telephone number is (571)270-1862. The examiner can normally be reached on Mon - Fri 8:30 am - 5:00 pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Shuwang Liu can be reached on (571) 272-3036. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/KENNETH LAM/

Primary Examiner, Art Unit 2631

Notice of References Cited	Application/Control No. 13/807,706	Applicant(s)/Patent Under Reexamination PARK, KYOUNGMIN	
	Examiner KENNETH LAM	Art Unit 2631	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2011/0305263	12-2011	J+e et al.	375/219
*	B	US-2011/0034192	02-2011	Lim et al.	455/501
*	C	US-2011/0249713	10-2011	Hammarwall et al.	375/220
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13807706	PARK, KYOUNGMIN
	Examiner	Art Unit
	KENNETH LAM	2631

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	05/28/2014	09/11/2014							
	1	✓	✓							
	2	✓	✓							
	3	✓	✓							
	4	✓	✓							
	5	✓	✓							
	6	O	O							
	7	✓	✓							
	8	O	O							
	9	O	O							
	10	✓	✓							
	11	✓	✓							
	12	✓	✓							
	13	✓	✓							
	14	✓	✓							
	15	O	O							
	16	✓	✓							
	17	✓	✓							
	18	✓	✓							
	19	✓	✓							
	20	✓	✓							
	21	✓	✓							
	22	O	O							
	23	O	O							
	24	O	O							
	25	✓	✓							
	26	✓	✓							
	27	✓	✓							
	28	✓	✓							
	29	O	O							
	30	O	O							
	31	O	O							

RESPONSE UNDER 37 CFR 1.116
EXPEDITED PROCEDURE
GROUP ART UNIT 2631

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:	Docket No.: P5158US00
Kyoungmin PARK	
Serial No.: 13/807,706	Group Art Unit: 2631
Confirmation No.: 9187	
Filed: December 28, 2012	Examiner: LAM, KENNETH T

For: **TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH**

Mail Stop: AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REPLY UNDER 37 C.F.R. § 1.116

Madam:

In response to the Final Office Action dated September 17, 2014 ("Office Action"), Applicant respectfully requests reconsideration of the application in view of the following Amendments and Remarks.

Amendments to the claims begin on page 2.

Remarks begin on page 13.

No extensions of time are required at this time. If extensions of time are necessary to prevent abandonment of this application, then they are petitioned for under 37 C.F.R. § 1.136(a). No fees for net addition of claims are required at this time. Any fees required for extensions of time or for the net addition of claims may be charged to our Deposit Account No. 50-3698.

AMENDMENTS TO THE CLAIMS

Please **AMEND** claims 1, 10, 18, and 25 as shown below.

This claim list replaces all prior claim lists in the application.

1. (Currently Amended) A communication method of a transmitting device including a first precoder and a second precoder, the method comprising:

determining a first bit sequence to restrict at least one precoding matrix from a first precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, and the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of the first precoder;

determining a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the second precoding matrix group being restricted from being used as a precoding matrix of the second precoder; and

transmitting, to a receiving device, codebook restricting information including at least one of the first bit sequence and the second bit sequence,

wherein the precoding matrix of the first precoder is multiplied by the precoding matrix of the second precoder.

2. (Previously Presented) The method of claim 1, further comprising:

receiving, from the receiving device, 1st channel status information indicating the

precoding matrix of the first precoder and 2nd channel status information indicating the precoding matrix of the second precoder, the precoding matrix of the first precoder and the precoding matrix of the second precoder selected by the receiving device based on the first bit sequence and the second bit sequence, respectively; and

precoding data symbols through the first precoder and the second precoder using the precoding matrix corresponding to the received 1st channel status information and the precoding matrix corresponding to the 2nd status information, and transmitting the precoded data symbols.

3. (Previously Presented) The method of claim 1, wherein the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

4. (Previously Presented) The method of claim 1, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence.

5. (Previously Presented) The method of claim 1, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and

the second domain.

6. (Previously Presented) The method of claim 5, wherein the precoding matrix of the first precoder corresponds to W1 in the following Equation, and the precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

7. (Original) The method of claim 5, wherein a number of the antenna pairs corresponds to 4.

8. (Original) The method of claim 2, wherein, in receiving of the 1st channel status information and the 2nd channel status information, a period of receiving the 1st channel status information and a period of receiving the 2nd channel status information are different from each other.

9. (Original) The method of claim 8, wherein the period of receiving the 1st channel status information is longer than the period of receiving the 2nd channel status information.

10. (Currently Amended) A transmitting device, the device comprising:

a layer mapper to map a codeword to a layer;

a precoder configured to precode a data symbol corresponding to the codeword mapped to the layer by the layer mapper, the precoder precoding the data symbol using a precoding matrix of a first precoder and a precoding matrix of a second precoder selected from corresponding codebooks; and

an antenna array to transmit signals output from the precoder, the signals including at least one of a first bit sequence and a second bit sequence,

wherein the first bit sequence restricts at least one precoding matrix from a first precoding matrix group, the at least one precoding matrix of the first precoding matrix group being restricted from being used as the precoding matrix of the first precoder,

wherein the second bit sequence restricts at least one precoding matrix from a second precoding matrix group, the at least one precoding matrix of the second precoding matrix group being restricted from being used as the precoding matrix of the second precoder, [[and]]

wherein each bit of the first bit sequence corresponds to one precoding matrix of the first precoding matrix group, respectively, and each bit of the second bit sequence corresponds to one precoding matrix of the second precoding matrix group, respectively, and

wherein the precoding matrix of the first precoder is multiplied by the precoding matrix of the second precoder.

11. (Previously Presented) The device of claim 10, wherein the antenna array receives 1st channel status information indicating the precoding matrix of the first precoder and 2nd channel status information indicating the precoding matrix of the second precoder; and

the first precoder and the second precoder perform precoding on data symbols using the precoding matrix corresponding to the received 1st channel status information and the precoding

matrix corresponding to the received 2nd channel status information, respectively.

12. (Previously Presented) The device of claim 10, wherein the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

13. (Previously Presented) The device of claim 10, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence.

14. (Previously Presented) The device of claim 10, wherein the antenna array includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the-precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

15. (Previously Presented) The device of claim 14, wherein the precoding matrix of the first precoder corresponds to W1 in the following Equation, and the precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

16. (Original) The device of claim 14, wherein the first domain and the second domain intersect each other.

17. (Original) The device of claim 14, wherein a number of the antenna pairs corresponds to 4.

18. (Currently Amended) A communication method of a receiving device in a wireless communication system, the method comprising:

receiving codebook restricting information including at least one of a first bit sequence to restrict at least one precoding matrix from a first precoding matrix group and a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of a first precoder, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group,

respectively, and the at least one precoding matrix of the second precoding matrix group being restricted from being used as a precoding matrix of a second precoder; and

transmitting, to a transmitting device, 1st channel status information indicating the precoding matrix of the first precoder and 2nd channel status information indicating the precoding matrix of the second precoder, ~~the precoding matrix of the first precoder and the precoding matrix of the second precoder,~~ the precoding matrix of the first precoder and the precoding matrix of the second precoder being selected, based on the codebook restricting information, from among precoding matrices that are not restricted,

wherein the precoding matrix of the first precoder is multiplied by the precoding matrix of the second precoder.

19. (Previously Presented) The method of claim 18, wherein the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

20. (Previously Presented) The method of claim 18, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence.

21. (Previously Presented) The method of claim 18, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

22. (Previously Presented) The method of claim 21, wherein the precoding matrix of the first precoder corresponds to W1 in the following Equation and the precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

23. (Original) The method of claim 18, wherein, in transmitting, a period of transmitting the 1st channel status information and a period of transmitting the 2nd channel status information are different from each other.

24. (Original) The method of claim 23, wherein the period of transmitting the 1st channel status information is longer than the period of transmitting the 2nd channel status information.

25. (Currently Amended) A receiving device in a wireless communication system, the receiving device comprising:

an antenna array to receive, as codebook restricting information, at least one of a first bit sequence to restrict at least one precoding matrix from a first precoding matrix group and a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of a first precoder, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the second precoding matrix group being restricted from being used as a precoding matrix of a second precoder; and

a channel information feedback device to transmit, to a transmitting device, 1st channel status information indicating the precoding matrix of the first precoder and 2nd channel status information indicating the precoding matrix of the second precoder, the precoding matrix of the first precoder and the precoding matrix of the second precoder being selected, based on the codebook restricting information, from among precoding matrices that are not restricted,

wherein the precoding matrix of the first precoder is multiplied by the precoding matrix of the second precoder.

26. (Previously Presented) The device of claim 25, wherein the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

27. (Previously Presented) The device of claim 25, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first

matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence.

28. (Previously Presented) The device of claim 25, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

29. (Previously Presented) The device of claim 28, wherein the precoding matrix of the first precoder corresponds to W1 in the following Equation, and the precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

30. (Original) The device of claim 25, wherein a period of transmitting the 1st channel status information and a period of transmitting the 2nd channel status information are different from each other.

31. (Original) The device of claim 30, wherein the period of transmitting the 1st channel status information is longer than the period of transmitting the 2nd channel status information.

REMARKS

Claims 1, 10, 18, and 25 have been amended to incorporate features similar to claim 6 indicated as containing allowable subject matter. Accordingly, claims 1-31 are currently pending in the application, of which claims 1, 10, 18, and 25 are independent. Applicant appreciates the indication that claims 6, 8, 9, 15, 22-24, and 29-31 contain allowable subject matter.

Applicant respectfully submits that the above amendments do not add new matter to the Application and are fully supported by the specification. In view of the following Remarks, Applicant requests reconsideration and timely withdrawal of the pending rejections for the reasons discussed below.

Claim Objection

Claims 6, 8-9, 15, 22-24, 29-31 were objected to for containing allowable subject matter but being dependent upon a rejected base claim.

Claims have not been amended because Applicant respectfully submits that claims 6, 8-9, 15, 22-24, 29-31 depend from an allowable base claim and are allowable at least for this reason.

Accordingly, Applicant respectfully requests withdrawal of the objection for claims 6, 8-9, 15, 22-24, 29-31.

Rejections Under 35 U.S.C. § 103

To establish an obviousness rejection under 35 U.S.C. § 103(a), four factual inquiries must be examined. The four factual inquiries include (a) determining the scope and contents of the prior art; (b) ascertaining the differences between the prior art and the claims in issue; (c)

resolving the level of ordinary skill in the pertinent art; and (d) evaluating evidence of secondary consideration. *Graham v. John Deere*, 383 U.S. 1, 17-18 (1966).

In view of these four factors, the analysis supporting a rejection under 35 U.S.C. 103(a) should be made explicit, and should "identify a reason that would have prompted a person of ordinary skill in the relevant field to combine the [prior art] elements" in the manner claimed. *KSR Int'l. Co. v. Teleflex, Inc.*, 127 S. Ct. 1727, 82 USPQ2d 1385, 1396 (2007). The Federal Circuit requires that "rejections on obviousness cannot be sustained with mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness." *In re Kahn*, 441 F.3d 977, 988, 78 USPQ2d 1329, 1336 (Fed. Cir. 2006).

Finally, even if the prior art may be combined, there must be a reasonable expectation of success, and the reference or references, when combined, must disclose or suggest every claimed feature. *See in re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

Claims 1-4, 10-13, 18-20, and 25-27 stand rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over U.S. Patent Application Publication No. 2011/0249713, applied for by Hammarwall, *et al*. ("Hammarwall") in view of U.S. Patent Application Publication No. 2011/0034192, applied for by Lim, *et al*. ("Lim").

Amended claim 1 recites, *inter alia*:

> determining a first bit sequence to restrict at least one precoding matrix from a first precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, and the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of the first precoder;
> determining a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at

least one precoding matrix of the second precoding matrix group being restricted from being used as a precoding matrix of the second precoder; …
wherein the precoding matrix of the first precoder is multiplied by the precoding matrix of the second precoder. (emphasis added).

The Office Action states Hammarwall discloses "determining a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group" because Hammarwall's paragraph [0069] allegedly discloses "mode 2". Office Action at page 3. Without conceding to the correctness of the Examiner's assertions, claim 1 has been amended to incorporate features similar to allowable claim 6 for further clarification and to advance prosecution.

Hammarwall discloses "the transceiver 12 is configured to manage the codebook 26 as two or more predetermined subsets 50 by associating a first plurality 56 of precoders 28 in **the codebook 26** with a **first operating mode** and associating a second plurality 58 of precoders 28 in **the codebook 26** with a **second operating mode**." Hammarwall, paragraph [0069]. (emphasis added). In other words, the first plurality 56 of precoders 28 and the second plurality 58 of precoders 28 are included in the same codebook 26. However, Hammarwall does not disclose or suggest that two precoding matrices from the same codebook 26 are multiplied.

Further, Hammarwall discloses "the first plurality 56 of precoders 28 is intended for use in a particular operating mode, while the second plurality 58 of precoders 28 is intended for use in a different operating mode. The first mode is, for example, SU-MIMO, while the second mode is MU-MIMO". *Id.* However, Hammarwall does not disclose or suggest a precoding matrix of the first operating mode and a precoding matrix of the second operating mode are multiplied. Applicant respectfully submits that the first operating mode, e.g., the Single-User Multiple Input Multiple Output (SU-MIMO), and the second operating mode, e.g., the Multi-User Multiple Input Multiple Output (MU-MIMO), are independent operating modes, and that a precoding matrix of

for the SU-MIMO is not multiplied by a precoding matrix for the MU-MIMO. Therefore, Hammarwall does not disclose or suggest "wherein the precoding matrix of the first precoder is multiplied by the precoding matrix of the second precoder" as recited in amended claim 1.

Further, in the Office Action, the Examiner acknowledges that "Hammarwall discloses the claimed invention except explicitly teaches the precoding matrix." Office Action at page 4. As discussed above, Applicant respectfully notes that the deficiencies are not limited to the omission of the precoding matrix. Thus, the Office Action fails to establish a *prima facie* case of obviousness of claim 1 at least because, even if combined, Hammarwall and Lim fail to disclose or suggest every claimed feature.

Next, the Office Action relies upon Lim's paragraph [0078] to cure the deficiencies of Hammarwall. *Id*. at page 4. Specifically, the Office Action alleges that "Lim discloses used precoding matrix cause strong affects to a neighbor cell and embodiments to [reduce] the flashlight effect ([0078]). Therefore, it would have been obvious to one skilled in the art at the time the invention was made to utilize the teaching by Lim with the invention taught by Hammarwall to achieve the same expected results of restricting at least one precoding matrix from a first precoding matrix group." *Id*. However, as noted above, Hammarwall's deficiencies are not limited to the omission of the precoding matrix, and Lim does not cure the noted deficiencies. Even if Lim properly discloses a precoding matrix, which Applicant does not concede, the Office Action is silent as to how Lim's teaching could be used to modify the structure of Hammarwall to implement the feature recited in claim 1. Without introducing impermissible hindsight, the Examiner must provide some articulated reasoning as to how Hammarwall's configuration could be modified by Lim's specific teachings to suggest the claimed feature as a whole by stepping "backward in time and into the shoes worn by the "hypothetical person of ordinary skill in the art"". MPEP 2142. Here, the Office Action fails to

provide such rationale, and therefore fails to establish a *prima facie* case of obviousness of claim 1.

Amended claims 10, 18, and 25 features similar to those discussed above with respect to amended claim 1, and therefore, are patentable for at least similar reasons as those discussed above with respect to amended claim 1.

Accordingly, Applicant respectfully requests withdrawal of the 35 U.S.C. § 103(a) rejection of claim 1, 10, 18, and 25. Claims 2-4, 11-13, 19, 20, 26, and 27 depend from one of claims 1, 10, 18, and 25 and are allowable at least for this reason. Since none of the other prior art of record, whether taken alone or in any combination, discloses or suggests all the features of the claimed invention, Applicant submits that independent claims 1, 10, 18, and 25, and all the claims that depend therefrom, are allowable.

Claims 5, 7, 14, 16, 17, 21, and 28 stand rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over Hammarwall and Lim further in view of U.S. Patent Application Publication No. 2011/0305263, applied for by Jongren, *et al*. ("Jongren"). Applicant respectfully traverses this rejection for at least the following reasons.

Applicant respectfully submits that claims 1, 10, 18, and 25 are allowable over Hammarwall and Lim, and Jongren fails to cure the deficiencies of Hammarwall and Lim noted above with regard to claim 1. Hence, claims 5, 7, 14, 16, 17, 21, and 28 are allowable at least because they depend from an allowable base claim.

Allowable Subject Matter

Applicant appreciates the indication that claims 6, 8, 9, 15, 22-24, and 29-31 contain allowable subject matter. Applicant respectfully submits that claims 1, 10, 18, and 25 are

allowable over the cited references and claims 6, 8, 9, 15, 22-24, and 29-31 depend therefrom are allowable at least because they depend from an allowable base claim.

Accordingly, Applicant submits that claims 6, 8, 9, 15, 22-24, and 29-31 are in condition for allowance.

CONCLUSION

A full and complete response has been made to the pending Office Action, and all of the stated grounds for rejection have been overcome or rendered moot. Accordingly, all pending claims are allowable, and the application is in condition for allowance.

The Examiner is invited to contact Applicant's undersigned representative at the number below if it would expedite prosecution. Prompt and favorable consideration of this Reply is respectfully requested.

Respectfully submitted,

/dongil moon/

Dongil Moon
Reg. No. L0830

Date: November 14, 2014

CUSTOMER NUMBER: 58027
H.C. Park & Associates, PLC
1894 Preston White Drive
Reston, VA 20191
Tel: 703-288-5105
Fax: 703-288-5139
HCP/DM/py

Electronic Acknowledgement Receipt

EFS ID:	20705081
Application Number:	13807706
International Application Number:	
Confirmation Number:	9187
Title of Invention:	TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH
First Named Inventor/Applicant Name:	Kyoungmin Park
Customer Number:	58027
Filer:	Hae-Chan Park
Filer Authorized By:	
Attorney Docket Number:	P5158US00
Receipt Date:	14-NOV-2014
Filing Date:	28-DEC-2012
Time Stamp:	17:03:53
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		P5158US00_AS-FILED_Reply_to_FOA.pdf	169312 cdf091f3f79773ad70c6e8d0471518bc2c6f9047	yes	19

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Response After Final Action	1	1
	Claims	2	12
	Applicant Arguments/Remarks Made in an Amendment	13	19
Warnings:			
Information:			
	Total Files Size (in bytes):	169312	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
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New International Application Filed with the USPTO as a Receiving Office
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PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/807,706	Filing Date 12/28/2012	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT **11/14/2014**

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 31	Minus	** 31	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 4	Minus	***4	= 0	X $420 =	0
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	0

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/KAREN VESTAL/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/807,706	12/28/2012	Kyoungmin Park	P5158US00	9187

58027 7590 11/21/2014

H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191

EXAMINER
LAM, KENNETH T

ART UNIT	PAPER NUMBER
2631	

NOTIFICATION DATE	DELIVERY MODE
11/21/2014	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

PATENT@PARK-LAW.COM

Advisory Action Before the Filing of an Appeal Brief	**Application No.** 13/807,706	**Applicant(s)** PARK, KYOUNGMIN	
	Examiner KENNETH LAM	**Art Unit** 2631	**AIA (First Inventor to File) Status** No

--The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

THE REPLY FILED 14 November 2014 FAILS TO PLACE THIS APPLICATION IN CONDITION FOR ALLOWANCE.

NO NOTICE OF APPEAL FILED

1. ☐ The reply was filed after a final rejection. No Notice of Appeal has been filed. To avoid abandonment of this application, applicant must timely file one of the following replies: (1) an amendment, affidavit, or other evidence, which places the application in condition for allowance; (2) a Notice of Appeal (with appeal fee) in compliance with 37 CFR 41.31; or (3) a Request for Continued Examination (RCE) in compliance with 37 CFR 1.114 if this is a utility or plant application. Note that RCEs are not permitted in design applications. The reply must be filed within one of the following time periods:
   a) ☐ The period for reply expires _____months from the mailing date of the final rejection.
   b) ☒ The period for reply expires on: (1) the mailing date of this Advisory Action; or (2) the date set forth in the final rejection, whichever is later. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of the final rejection.
   c) ☐ A prior Advisory Action was mailed more than 3 months after the mailing date of the final rejection in response to a first after-final reply filed within 2 months of the mailing date of the final rejection. The current period for reply expires months from the mailing date of *the prior Advisory Action* or SIX MONTHS from the mailing date of the final rejection, whichever is earlier.

   Examiner Note: If box 1 is checked, check either box (a), (b) or (c). ONLY CHECK BOX (b) WHEN THIS ADVISORY ACTION IS THE FIRST RESPONSE TO APPLICANT'S FIRST AFTER-FINAL REPLY WHICH WAS FILED WITHIN TWO MONTHS OF THE FINAL REJECTION. ONLY CHECK BOX (c) IN THE LIMITED SITUATION SET FORTH UNDER BOX (c). See MPEP 706.07(f).

Extensions of time may be obtained under 37 CFR 1.136(a). The date on which the petition under 37 CFR 1.136(a) and the appropriate extension fee have been filed is the date for purposes of determining the period of extension and the corresponding amount of the fee. The appropriate extension fee under 37 CFR 1.17(a) is calculated from: (1) the expiration date of the shortened statutory period for reply originally set in the final Office action; or (2) as set forth in (b) or (c) above, if checked. Any reply received by the Office later than three months after the mailing date of the final rejection, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

NOTICE OF APPEAL

2. ☐ The Notice of Appeal was filed on _____. A brief in compliance with 37 CFR 41.37 must be filed within two months of the date of filing the Notice of Appeal (37 CFR 41.37(a)), or any extension thereof (37 CFR 41.37(e)), to avoid dismissal of the appeal. Since a Notice of Appeal has been filed, any reply must be filed within the time period set forth in 37 CFR 41.37(a).

AMENDMENTS

3. ☒ The proposed amendments filed after a final rejection, but prior to the date of filing a brief, will not be entered because
   a) ☒ They raise new issues that would require further consideration and/or search (see NOTE below);
   b) ☐ They raise the issue of new matter (see NOTE below);
   c) ☐ They are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal; and/or
   d) ☐ They present additional claims without canceling a corresponding number of finally rejected claims.

   NOTE: *See Continuation Sheet*. (See 37 CFR 1.116 and 41.33(a)).

4. ☐ The amendments are not in compliance with 37 CFR 1.121. See attached Notice of Non-Compliant Amendment (PTOL-324).
5. ☐ Applicant's reply has overcome the following rejection(s): _____.
6. ☐ Newly proposed or amended claim(s) _____ would be allowable if submitted in a separate, timely filed amendment canceling the non-allowable claim(s).
7. ☒ For purposes of appeal, the proposed amendment(s): (a) ☒ will not be entered, or (b) ☐ will be entered, and an explanation of how the new or amended claims would be rejected is provided below or appended.

AFFIDAVIT OR OTHER EVIDENCE

8. ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.
9. ☐ The affidavit or other evidence filed after final action, but before or on the date of filing a Notice of Appeal will not be entered because applicant failed to provide a showing of good and sufficient reasons why the affidavit or other evidence is necessary and was not earlier presented. See 37 CFR 1.116(e).
10. ☐ The affidavit or other evidence filed after the date of filing the Notice of Appeal, but prior to the date of filing a brief, will not be entered because the affidavit or other evidence failed to overcome all rejections under appeal and/or appellant fails to provide a showing of good and sufficient reasons why it is necessary and was not earlier presented. See 37 CFR 41.33(d)(1).
11. ☐ The affidavit or other evidence is entered. An explanation of the status of the claims after entry is below or attached.

REQUEST FOR RECONSIDERATION/OTHER

12. ☐ The request for reconsideration has been considered but does NOT place the application in condition for allowance because: _____.
13. ☐ Note the attached Information *Disclosure Statement*(s). (PTO/SB/08) Paper No(s). _____
14. ☐ Other: _____.

STATUS OF CLAIMS

15. The status of the claim(s) is (or will be) as follows:
    Claim(s) allowed: .
    Claim(s) objected to: 6,8,9,15,22-24 and 29-31.
    Claim(s) rejected: 1-5,7,10-14,16-21 and 25-28.
    Claim(s) withdrawn from consideration: .

/KENNETH LAM/
Primary Examiner, Art Unit 2631

Continuation of 3. NOTE: The amendment changes the scope of the invention and therefore new search and further consideration are required.

PTO/SB/30EFS (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	13807706	Filing Date	2012-12-28	Docket Number (if applicable)	P5158US00	Art Unit	2631
First Named Inventor	Kyoungmin PARK			Examiner Name	LAM, KENNETH T		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☒ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____

☐ Other _____

☐ Enclosed

☐ Amendment/Reply

☐ Information Disclosure Statement (IDS)

☐ Affidavit(s)/ Declaration(s)

☐ Other _____

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____
(Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.
☒ The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 503698

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

☐ Applicant Signature

PTO/SB/30EFS (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Signature of Registered U.S. Patent Practitioner			
Signature	/dongil moon/	Date (YYYY-MM-DD)	2014-12-17
Name	Dongil Moon	Registration Number	L0830

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	13807706
Filing Date:	28-Dec-2012
Title of Invention:	TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH
First Named Inventor/Applicant Name:	Kyoungmin Park
Filer:	Hae-Chan Park/Sheryll Jenkins
Attorney Docket Number:	P5158US00

Filed as Large Entity

Filing Fees for U.S. National Stage under 35 USC 371

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for Continued Examination	1801	1	1200	1200
		Total in USD ($)		**1200**

Electronic Acknowledgement Receipt

EFS ID:	20987073
Application Number:	13807706
International Application Number:	
Confirmation Number:	9187
Title of Invention:	TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH
First Named Inventor/Applicant Name:	Kyoungmin Park
Customer Number:	58027
Filer:	Hae-Chan Park
Filer Authorized By:	
Attorney Docket Number:	P5158US00
Receipt Date:	17-DEC-2014
Filing Date:	28-DEC-2012
Time Stamp:	13:01:16
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$1200
RAM confirmation Number	10338
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Continued Examination (RCE)	P5158US00-RCE.pdf	1107002 1b733d03719ba8d0465f3b944ba27dadfbed3a82	no	3
Warnings:					
This is not a USPTO supplied RCE SB30 form.					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30754 8c93d4a86d1cf194e0c01dc358a9c2ca9c4bc37a	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	1137756		

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PTO/SB/06 (09-11)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/807,706	Filing Date 12/28/2012	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
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☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT **12/17/2014**

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 31	Minus	** 31	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 4	Minus	***4	= 0	X $420 =	0
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	0

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/DENISE HOPKINS/

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If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/807,706	12/28/2012	Kyoungmin Park	P5158US00	9187

58027 7590 01/09/2015

H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191

EXAMINER	
LAM, KENNETH T	

ART UNIT	PAPER NUMBER
2631	

NOTIFICATION DATE	DELIVERY MODE
01/09/2015	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

PATENT@PARK-LAW.COM

Office Action Summary	Application No. 13/807,706	Applicant(s) PARK, KYOUNGMIN	
	Examiner KENNETH LAM	Art Unit 2631	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *12/17/2014*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1-31* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-5,7,10-14,16-21 and 25-28* is/are rejected.

8)☒ Claim(s) *6, 8, 9, 15, 22-24, 29-31* is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

DETAILED ACTION

1. The present application is being examined under the pre-AIA first to invent provisions.

Request for Continued Examination

2. The request filed on 12/17/2014 for a Request for Continued Examination (RCE) under 37 CFR 1.114 based on parent Application No. 13/807706 is acceptable and a RCE has been established. An action on the RCE follows.

Response to Amendment

3. Applicant's arguments filed 11/14/2014 have been fully considered but they are not persuasive. The examiner thoroughly reviewed Applicant's arguments but firmly believes that the cited reference reasonably and properly meets the claimed limitation as rejected.

> **Applicant's arguments:** "The Office Action states Hammarwall discloses "determining a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group" because Hammarwall's paragraph [0069] allegedly discloses "mode 2". Office Action at page 3. Without conceding to the correctness of the Examiner's assertions, claim 1 has been amended to incorporate features similar to allowable claim 6 for further clarification and to advance prosecution."

The examiner's response: Hammarwall discloses codebook containing conversion precoders and tuning precoders ([0074]). Hammarwall further discloses precoder restrictions generated and signaled in terms of which ones of the overall precoders are permitted for use, or, equivalently, in terms of which ones of the conversion precoders and/or tuning precoders are permitted for use ([0075]). Therefore, Hammarwall discloses bit sequences to restrict at least one precoding matrix from a second precoding matrix group (precoder restriction for the tuning precoder). Hammarwall discloses the codebook and wherein the precoders are using similar matrix/vector structures except explicitly teaches precoding matrix, it would have been obvious to one skilled in the art at the time the invention was made to utilize the precoding matrix in codebook as disclosed by Lim.

Claim Rejections - 35 USC § 103

4. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under pre-AIA 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

5. Claims 1-4, 10-13, 18-20, 25-27 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Hammarwall et al. (US 2011/0249713 A1) (Hammarwall herein after) in view of Lim et al. (US 2011/0034192 A1) (Lim herein after).

Re Claim 1, Hammarwall discloses a communication method of a transmitting device including a first precoder and a second precoder, the method comprising:

determining a first bit sequence (restriction signal M-length bit mark and one or more binary values, [0071]) to restrict at least one precoding matrix from a first precoding matrix group, (mode indicator, [0062], conversion precoder, [0058]), each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group (subset could be single precoder, [0071], precoder restrictions may be generated and signaled in terms of which ones of the overall precoders are permitted for use, [0077]), respectively, and the at least one precoding matrix of the first precoding

matrix group being restricted from being used as a precoding matrix of the first precoder (mode indicator, rank information, [0062], [0091], restrict precoder selection, [0074]);

determining a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group (Mode 2, [0069]), each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the second precoding matrix group being restricted from being used as a precoding matrix of the second precoder (mode indicator, rank information, [0062], [0091], precoder restrictions may be generated and signaled in terms of which ones of the overall precoders are permitted for use, [0077]); and

transmitting, to a receiving device, codebook restricting information (restriction signal, [0062]) including at least one of first bit sequence and the second bit sequence,

wherein the precoding matrix of the first precoder is mulitpled by the precoding matrix of the second precoder (conversion precoder multiply by the tuning precoder, [0096], Figure 11).

Hammarwall discloses the claimed invention wherein the precoders are using similar matrix/vector structures ([0072]) except explicitly teaches the precoding matrix. However, Lim discloses used precoding matrix cause strong affects to a neighbor cell and embodiments to reduece the flashlight effect ([0078]). Therefore, it would have been obvious to one skilled in the art at the time the invention was made to utilize the teaching by Lim with the invention taught by Hammarwall to achieve the same expected

results of restricting at least one precoding matrix from a first precoding matrix group.

Re Claim 2, Hammarwall discloses the method of claim 1, further comprising:

receiving, from the receiving device, 1st channel status information indicating the precoding matrix of the first precoder and 2nd channel status information indicating the precoding matrix of the second precoder (transceiver 12 receive restriction signal, [0062]), the precoding matrix or the first precoder and the precoding matrix of the second precoder selected by the receiving device based on the first bit sequence and the second bit sequence, respectively (PMI values, [0061]); and

precoding data symbols through the first precoder and the second precoder using the precoding matrix corresponding to the received 1st channel status information and the precoding matrix corresponding to the 2nd status information (conversion precoder, tuning precoder, [0058], CSI, [0113]-[0114]), and transmitting the precoded data symbols.

Re Claim 3, Hammarwall discloses the method of claim 1, wherein the first matrix group includes N precoding matrices (precoding matrices utilized in precoder, [0059]), and the first bit sequence is an N-bit sequence, where N is an integer (bitmap-based signaling, [0010], restriction signal M-length bit mark and one or more binary values, [0071]).

Re Claim 4, Hammarwall discloses the method of claim 1, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence (mode indicator, rank information, [0062], [0091], restriction signal M-length bit mark and one or more binary values, [0071]).

Re Claim 10, Hammarwall discloses a transmitting device, the device comprising:

a layer mapper to map a codeword to a layer (layer processing circuitry, [0092]);

a precoder (tuning precoder, [0058], mode indicator, [0062], conversion precoder, [0058]) configured to precode a data symbol corresponding to the codeword mapped to the layer by the layer mapper, the precoder precoding the data symbol using a precoding matrix of a first precoder and a precoding matrix of a second precoder selected from corresponding codebooks (PMI values, [0061]); and

an antenna array to transmit signals output from the precoder, the signals including at least one of a first bit sequence and a second bit sequence (restriction signal M-length bit mark and one or more binary values, [0071]),

wherein the first bit sequence (restriction signal M-length bit mark and one or more binary values, [0071]) restricts at least one precoding matrix from a first precoding matrix group, (mode indicator, [0062], conversion precoder, [0058], precoder restrictions may be generated and signaled in terms of which ones of the overall precoders are

permitted for use, [0077]), the at least one precoding matrix of the first precoding matrix group being restricted from being used as the precoding matrix of the first precoder (mode indicator, rank information, [0062], [0091], restrict precoder selection, [0074]);

wherein the second bit sequence restricts at least one precoding matrix from a second precoding matrix group (Mode 2, [0069]), the at least one precoding matrix of the second precoding matrix group being restricted from being used as the precoding matrix of the second precoder (mode indicator, rank information, [0062], [0091], precoder restrictions may be generated and signaled in terms of which ones of the overall precoders are permitted for use, [0077]), and

wherein each bit of the first bit sequence corresponds to one precoding matrix of the first precoding matrix group, respectively, and each bit of the second bit sequence corresponds to one precoding matrix of the second precoding matrix group, respectively (mode indicator, rank information, [0062], [0091], restrict precoder selection, [0074]), and

wherein the precoding matrix of the first precoder is mulitpled by the precoding matrix of the second precoder (conversion precoder multiply by the tuning precoder, [0096], Figure 11).

Hammarwall discloses the claimed invention wherein the precoders are using similar matrix/vector structures ([0072]) except explicitly teaches the precoding matrix. However, Lim discloses used precoding matrix cause strong affects to a neighbor cell and embodiments to reduece the flashlight effect ([0078]). Therefore, it would have been obvious to one skilled in the art at the time the invention was made to utilize the

teaching by Lim with the invention taught by Hammarwall to achieve the same expected results of restricting at least one precoding matrix from a first precoding matrix group.

Re Claim 11, Hammarwall discloses the device of claim 10, wherein the antenna array receives 1st channel status information indicating the precoding matrix of the first precoder and 2nd channel status information indicating the precoding matrix of the second precoder (transceiver 12 receive restriction signal, [0062]); and

the first precoder and the second precoder perform precoding on data symbols using the precoding matrix corresponding to the received 1st channel status information and the precoding matrix corresponding to the received 2nd channel status information (conversion precoder, tuning precoder, [0058], CSI, [0113]-[0114]), respectively.

Re Claim 12, Hammarwall discloses the device of claim 10, wherein the first matrix group includes N precoding matrices (precoding matrices utilized in precoder, [0059]), and the first bit sequence is an N-bit sequence, where N is an integer (bitmap-based signaling, [0010], restriction signal M-length bit mark and one or more binary values, [0071]).

Re Claim 13, Hammarwall discloses the device of claim 10, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding

matrices of the second matrix group is restricted based on the second bit sequence (mode indicator, rank information, [0062], [0091], restriction signal M-length bit mark and one or more binary values, [0071]).

Re Claims 18 and 25, Hammarwall discloses a communication method of a receiving device in a wireless communication system and a receiving device in a wireless communication system, the method and the device comprising:

receiving codebook restricting information (restriction signal, [0062]) including at least one of a first bit sequence to restrict at least one precoding matrix from a first precoding matrix group and a second bit sequence (Mode 2, [0069]) to restrict at least one precoding matrix from a second precoding matrix group (restriction signal M-length bit mark and one or more binary values, [0071]), each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of a first precoder, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the second precoding matrix group being restrcited from being used as a precoding matrix of a second precoder (mode indicator, [0062], conversion precoder, [0058], precoder restrictions may be generated and signaled in terms of which ones of the overall precoders are permitted for use, [0077]); and

transmitting, to a transmitting device, 1st channel status information indicating the precoding matrix of the first precoder and 2nd channel status information indicating the precoding matrix of the second precoder (transceiver 12 receive restriction signal, [0062]), the precoding matrix of the first precoder and the precoding matrix of the second precoder being selected, based on the codebook restricting information (mode indicator, rank information, [0062], [0091]), from among precoding matrices that are not restricted (conversion precoder, tuning precoder, [0058], CSI, [0113]-[0114]),

wherein the precoding matrix of the first precoder is mulitpled by the precoding matrix of the second precoder (conversion precoder multiply by the tuning precoder, [0096], Figure 11).

Hammarwall discloses the claimed invention wherein the precoders are using similar matrix/vector structures ([0072]) except explicitly teaches the precoding matrix. However, Lim discloses used precoding matrix cause strong affects to a neighbor cell and embodiments to reduece the flashlight effect ([0078]). Therefore, it would have been obvious to one skilled in the art at the time the invention was made to utilize the teaching by Lim with the invention taught by Hammarwall to achieve the same expected results of restricting at least one precoding matrix from a first precoding matrix group.

Re Claims 19 and 26, the combined teachings disclose the method of claim 18 and the device of claim 25, Hammarwall discloses wherein the first matrix group includes N precoding matrices (precoding matrices utilized in precoder, [0059]), and the

first bit sequence is an N-bit sequence, where N is an integer (bitmap-based signaling, [0010], restriction signal M-length bit mark and one or more binary values, [0071]).

Re Claims 20 and 27, the combined teachings disclose the method of claim 18 and the device of claim 25, Hammarwall discloses wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence (mode indicator, rank information, [0062], [0091], restriction signal M-length bit mark and one or more binary values, [0071]).

6. Claims 5, 7, 14, 16-17, 21, 28 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Hammarwall et al. (US 2011/0249713 A1) (Hammarwall herein after) and Lim et al. (US 2011/0034192 A1) (Lim herein after), further in view of Jongren et al. (US 2011/0305263 A1) (Jongren herein after).

Re Claim 5, the combined teachings disclose the method of claim 1, except explicitly teaches wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the precoding matrix of the first precoder performs precoding on the

first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

However, Jongren discloses a methods providing precoder feedback using multiple precoder indices wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other (polarization orthogonal, [0054]); and the first precoding matrix performs precoding on the first domain and the second domain (conversion precoder, [0059]), separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain (selection and adjustment precoders, [0059], phase adjustment).

Therefore, it would have been obvious at the time the invention was made to one of ordinary skill in the art to modify the system and method of Hammarwall, by making use of the technique taught by Jongren, in order to improve the closed loop precoder selection.

Both references are within the same field of digital communication, and in particular of MIMO system, the modification does not change a fundamental operating principle of Hammarwall, nor does Hammarwall teach away from the modification (Hammarwall merely discloses a preferred embodiment). The combination has a reasonable expectation of success in that the modifications can be made using conventional and well known engineering and/or programming techniques, the method

and system taught by Jongren is not altered and continues to perform the same function as separately, and the resultant combination produces the highly predictable result of wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

Re Claim 7, the combined teachings disclose the method of claim 5, Jongren discloses wherein a number of the antenna pairs corresponds to 4 (NT antenna elements and NT could be 4, [0054]).

Re Claim 14, the combined teachings disclose the device of claim 10, except explicitly teaches wherein the antenna array includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

However, Jongren discloses a methods providing precoder feedback using multiple precoder indices wherein the antenna array includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other (polarization orthogonal, [0054]); and the precoding matrix of the first precoder performs precoding on the first domain and the second domain (conversion precoder, [0059]), separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain (selection and adjustment precoders, [0059], phase adjustment).

Therefore, it would have been obvious at the time the invention was made to one of ordinary skill in the art to modify the system and method of Hammarwall, by making use of the technique taught by Jongren, in order to improve the closed loop precoder selection.

Both references are within the same field of digital communication, and in particular of MIMO system, the modification does not change a fundamental operating principle of Hammarwall, nor does Hammarwall teach away from the modification (Hammarwall merely discloses a preferred embodiment). The combination has a reasonable expectation of success in that the modifications can be made using conventional and well known engineering and/or programming techniques, the method and system taught by Jongren is not altered and continues to perform the same function as separately, and the resultant combination produces the highly predictable result of

wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

Re Claim 16, the combined teachings disclose the device of claim 14, Jongren discloses wherein the first domain and the second domain intersect each other (polarization orthogonal, [0054]).

Re Claim 17, the combined teachings disclose the device of claim 14, Jongren discloses wherein a number of the antenna pairs corresponds to 4 (NT antenna elements and NT could be 4, [0054]).

Re Claims 21 and 28, the combined teachings disclose the method of claim 18 and the device of claim 25, except explicitly teaches wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the

precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

However, Jongren discloses a methods providing precoder feedback using multiple precoder indices wherein the antenna array includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other (polarization orthogonal, [0054]); and the precoding matrix of the first precoder performs precoding on the first domain and the second domain (conversion precoder, [0059]), separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain (selection and adjustment precoders, [0059], phase adjustment).

Therefore, it would have been obvious at the time the invention was made to one of ordinary skill in the art to modify the system and method of Hammarwall, by making use of the technique taught by Jongren, in order to improve the closed loop precoder selection.

Both references are within the same field of digital communication, and in particular of MIMO system, the modification does not change a fundamental operating principle of Hammarwall, nor does Hammarwall teach away from the modification (Hammarwall merely discloses a preferred embodiment). The combination has a reasonable expectation of success in that the modifications can be made using

conventional and well known engineering and/or programming techniques, the method and system taught by Jongren is not altered and continues to perform the same function as separately, and the resultant combination produces the highly predictable result of wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and the first precoding matrix performs precoding on the first domain and the second domain, separately, and the second precoding matrix performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

Allowable Subject Matter

7. Claims 6, 8-9, 15, 22-24, 29-31 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to KENNETH LAM whose telephone number is (571)270-1862. The examiner can normally be reached on Mon - Fri 8:30 am - 5:00 pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Shuwang Liu can be reached on (571) 272-3036. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/KENNETH LAM/
Primary Examiner, Art Unit 2631

Notice of References Cited	Application/Control No. 13/807,706	Applicant(s)/Patent Under Reexamination PARK, KYOUNGMIN	
	Examiner KENNETH LAM	Art Unit 2631	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2011/0249713	10-2011	Hammarwall et al.	375/220
*	B	US-2011/0034192	02-2011	Lim et al.	455/501
*	C	US-2011/0305263	12-2011	J+e et al.	375/219
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13807706	PARK, KYOUNGMIN
	Examiner	Art Unit
	KENNETH LAM	2631

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	05/28/2014	09/11/2014	01/05/2015						
	1	✓	✓	✓						
	2	✓	✓	✓						
	3	✓	✓	✓						
	4	✓	✓	✓						
	5	✓	✓	✓						
	6	O	O	O						
	7	✓	✓	✓						
	8	O	O	O						
	9	O	O	O						
	10	✓	✓	✓						
	11	✓	✓	✓						
	12	✓	✓	✓						
	13	✓	✓	✓						
	14	✓	✓	✓						
	15	O	O	O						
	16	✓	✓	✓						
	17	✓	✓	✓						
	18	✓	✓	✓						
	19	✓	✓	✓						
	20	✓	✓	✓						
	21	✓	✓	✓						
	22	O	O	O						
	23	O	O	O						
	24	O	O	O						
	25	✓	✓	✓						
	26	✓	✓	✓						
	27	✓	✓	✓						
	28	✓	✓	✓						
	29	O	O	O						
	30	O	O	O						
	31	O	O	O						

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:	Docket No.: P5158US00
Kyoungmin PARK	
Serial No.: 13/807,706	Group Art Unit: 2631
Confirmation No.: 9187	
Filed: December 28, 2012	Examiner: LAM, KENNETH T

For: **TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH**

Mail Stop: Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REPLY UNDER 37 C.F.R. § 1.111

In response to the Non-Final Office Action mailed January 9, 2015 ("Office Action"), Applicant respectfully requests reconsideration of the Application in view of the following Amendments and Remarks.

Amendments to the Claims begin on page 2.

Remarks begin on page 14.

No extensions of time are required at this time. If extensions of time are necessary to prevent abandonment of this Application, then they are petitioned for under 37 C.F.R. § 1.136(a). No fees for net addition of claims are required at this time. Any fees required for extensions of time or for the net addition of claims may be charged to Deposit Account No. 50-3698.

AMENDMENTS TO THE CLAIMS

Please **CANCEL** claims 8, 23, and 30 without prejudice or disclaimer.

Please **AMEND** claims 1, 2, 9-11, 18, 24, 25, and 31 as shown below.

This claim list replaces all prior claim lists in the Application.

1. (Currently Amended) A communication method of a transmitting device including a first precoder and a second precoder, the method comprising:

determining a first bit sequence to restrict at least one precoding matrix from a first precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, and the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of the first precoder;

determining a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the second precoding matrix group being restricted from being used as a precoding matrix of the second precoder; and

transmitting, to a receiving device, codebook restricting information including at least one of the first bit sequence and the second bit sequence,

receiving, from the receiving device, information relating to the precoding matrix of the first precoder and information relating to the precoding matrix of the second precoder, and

wherein a period of receiving the information relating to the precoding matrix of the first precoder and a period of receiving the information relating to the precoding matrix of the second

precoder are different from each other

~~wherein the precoding matrix of the first precoder is multiplied by the precoding matrix of the second precoder~~.

2. (Currently Amended) The method of claim 1, further comprising:

~~receiving, from the receiving device, 1st channel status information indicating the precoding matrix of the first precoder and 2nd channel status information indicating the precoding matrix of the second precoder, the precoding matrix of the first precoder and the precoding matrix of the second precoder selected by the receiving device based on the first bit sequence and the second bit sequence, respectively; and~~

precoding data symbols through the first precoder and the second precoder using the precoding matrix of the first precoder and the precoding matrix of the second precoder; and~~corresponding to the received 1st channel status information and the precoding matrix corresponding to the 2nd status information, and~~

transmitting the precoded data symbols,

wherein the information relating to the precoding matrix of the first precoder and the information relating to the precoding matrix of the second precoder correspond to channel status information.

3. (Previously Presented) The method of claim 1, wherein the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

4. (Previously Presented) The method of claim 1, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first

matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence.

5. (Previously Presented) The method of claim 1, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

6. (Previously Presented) The method of claim 5, wherein the precoding matrix of the first precoder corresponds to W1 in the following Equation, and the precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

7. (Original) The method of claim 5, wherein a number of the antenna pairs corresponds to 4.

8. (Canceled)

9. (Currently Amended) The method of claim [[8]]1, wherein the period of receiving the ~~1st channel status~~ information relating to the precoding matrix of the first precoder is longer than the period of receiving the ~~2nd channel status~~ information relating to the precoding matrix of the second precoder.

10. (Currently Amended) A transmitting device, the device comprising:

a layer mapper to map a codeword to a layer;

a precoder configured to precode a data symbol corresponding to the codeword mapped to the layer by the layer mapper, the precoder precoding the data symbol using a precoding matrix of a first precoder and a precoding matrix of a second precoder selected from corresponding codebooks; and

an antenna array to transmit, to a receiving device, at least one of a first bit sequence and a second bit sequence, to receive, from the receiving device, information relating to the precoding matrix of the first precoder and information relating to the precoding matrix of the second precoder, and to transmit signals output from the precoder~~, the signals including at least one of a first bit sequence and a second bit sequence~~,

wherein the first bit sequence restricts at least one precoding matrix from a first precoding matrix group, the at least one precoding matrix of the first precoding matrix group being restricted from being used as the precoding matrix of the first precoder,

wherein the second bit sequence restricts at least one precoding matrix from a second

precoding matrix group, the at least one precoding matrix of the second precoding matrix group being restricted from being used as the precoding matrix of the second precoder,

wherein each bit of the first bit sequence corresponds to one precoding matrix of the first precoding matrix group, respectively, and each bit of the second bit sequence corresponds to one precoding matrix of the second precoding matrix group, respectively, and

wherein a period of receiving the information relating to the precoding matrix of the first precoder and a period of receiving the information relating to the precoding matrix of the second precoder are different from each other

~~wherein the precoding matrix of the first precoder is multiplied by the precoding matrix of the second precoder~~.

11. (Currently Amended) The device of claim 10, wherein the information relating to the precoding matrix of the first precoder and the information relating to the precoding matrix of the second precoder correspond to channel status information

~~the antenna array receives 1st channel status information indicating the precoding matrix of the first precoder and 2nd channel status information indicating the precoding matrix of the second precoder; and~~

~~the first precoder and the second precoder perform precoding on data symbols using the precoding matrix corresponding to the received 1st channel status information and the precoding matrix corresponding to the received 2nd channel status information, respectively~~.

12. (Previously Presented) The device of claim 10, wherein the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

13. (Previously Presented) The device of claim 10, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence.

14. (Previously Presented) The device of claim 10, wherein the antenna array includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

15. (Previously Presented) The device of claim 14, wherein the precoding matrix of the first precoder corresponds to W1 in the following Equation, and the precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and

the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

16. (Original) The device of claim 14, wherein the first domain and the second domain intersect each other.

17. (Original) The device of claim 14, wherein a number of the antenna pairs corresponds to 4.

18. (Currently Amended) A communication method of a receiving device in a wireless communication system, the method comprising:

receiving codebook restricting information including at least one of a first bit sequence to restrict at least one precoding matrix from a first precoding matrix group and a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of a first precoder, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the second precoding matrix group being restricted from being used as a precoding matrix of a second precoder; and

transmitting, to a transmitting device, 1st channel status information indicating the precoding matrix of the first precoder and 2nd channel status information indicating the precoding matrix of the second precoder, the precoding matrix of the first precoder and the precoding matrix of the second precoder being selected, based on the codebook restricting information, from among precoding matrices that are not restricted,

wherein a period of transmitting the information relating to the precoding matrix of the first precoder and a period of transmitting the information relating to the precoding matrix of the second precoder are different from each other

~~wherein the precoding matrix of the first precoder is multiplied by the precoding matrix of the second precoder~~.

19. (Previously Presented) The method of claim 18, wherein the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

20. (Previously Presented) The method of claim 18, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the first precoder that make pairs with restricted precoding matrices of the second matrix group is restricted based on the second bit sequence.

21. (Previously Presented) The method of claim 18, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

22. (Previously Presented) The method of claim 21, wherein the precoding matrix of the first precoder corresponds to W1 in the following Equation and the precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

23. (Canceled)

24. (Currently Amended) The method of claim [[23]]18, wherein the period of transmitting the ~~1st channel status~~ information relating to the precoding matrix of the first precoder is longer than the period of transmitting the ~~2nd channel status~~ information relating to the precoding matrix of the second precoder.

25. (Currently Amended) A receiving device in a wireless communication system, the receiving device comprising:

an antenna array to receive, as codebook restricting information, at least one of a first bit sequence to restrict at least one precoding matrix from a first precoding matrix group and a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first

precoding matrix group, respectively, the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of a first precoder, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the second precoding matrix group being restricted from being used as a precoding matrix of a second precoder; and

a channel information feedback device to transmit, to a transmitting device, ~~1st channel status~~ information ~~indicating~~relating to the precoding matrix of the first precoder and ~~2nd channel status~~ information ~~indicating~~relating to the precoding matrix of the second precoder, the precoding matrix of the first precoder and the precoding matrix of the second precoder being selected, based on the codebook restricting information, from among precoding matrices that are not restricted,

wherein a period of transmitting the information relating to the precoding matrix of the first precoder and a period of transmitting the information relating to the precoding matrix of the second precoder are different from each other

~~wherein the precoding matrix of the first precoder is multiplied by the precoding matrix of the second precoder~~.

26. (Previously Presented) The device of claim 25, wherein the first matrix group includes N precoding matrices, and the first bit sequence is an N-bit sequence, where N is an integer.

27. (Previously Presented) The device of claim 25, wherein the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the first matrix group is restricted based on the first bit sequence, and the use of precoding matrices for the second precoder that make pairs with restricted precoding matrices of the second matrix

group is restricted based on the second bit sequence.

28. (Previously Presented) The device of claim 25, wherein the transmitting device includes at least one antenna pair in which a first domain including at least one antenna polarized in one direction and a second domain including at least one antenna polarized in another direction intersect each other; and

the precoding matrix of the first precoder performs precoding on the first domain and the second domain, separately, and the precoding matrix of the second precoder performs phase mismatch correction to remove an effect from a phase mismatch between the first domain and the second domain.

29. (Previously Presented) The device of claim 28, wherein the precoding matrix of the first precoder corresponds to W1 in the following Equation, and the precoding matrix of the second precoder corresponds to W2 in the following Equation:

$$\mathbf{W} = \underbrace{\begin{pmatrix} R_0 & \mathbf{0} \\ \mathbf{0} & R_0 \end{pmatrix}}_{W_1} \underbrace{\begin{pmatrix} I \\ \Lambda \end{pmatrix}}_{W_2},$$

wherein R_0 denotes a value determined by a precoding gain when the first domain and the second domain have an identical spatial channel status, I denotes a unit matrix, and Λ denotes a phase mismatch correction value between the first domain and the second domain.

30. (Canceled)

31. (Currently Amended) The device of claim [[30]]25, wherein the period of transmitting the ~~1st channel status~~ information relating to the precoding matrix of the first precoder is longer than the period of transmitting the ~~2nd channel status~~ information relating to the precoding matrix of the second precoder.

REMARKS

Claims 1, 2, 9-11, 18, 24, 25, and 31 have been amended, and claims 8, 23, and 30 have been canceled without prejudice or disclaimer. Accordingly, claims 1-7, 9-22, 24-29, and 31 are currently pending in the Application, of which claims 1, 10, 18, and 25 are independent. Applicant appreciates the indication that claims 6, 8, 9, 15, 22-24, and 29-31 contain allowable subject matter.

Applicant respectfully submits that the above amendments do not add new matter to the Application and are fully supported by the specification.

In view of the above amendments and the following Remarks, Applicant respectfully requests reconsideration and timely withdrawal of the pending objections and rejections for the reasons discussed below.

Interview Summary

Applicant thanks the Examiner for the courtesies extended during the interview of March 27, 2015. The substance of the interview is addressed in the remarks below.

Claim Objection

Claims 6, 8, 9, 15, 22-24, and 29-31 were objected to for being dependent upon a rejected base claim.

Independent claims 1 and 10 have been amended to incorporate features related to the allowable subject matter of claim 8, and independent claims 18 and 25 have been amended to incorporate features related to the allowable subject matter of claims 23 and 30, respectively. Claims 8, 23, and 30 have been canceled, thereby rendering the objection moot. Applicant respectfully submits that independent claims 1, 10, 18, and 25 are in condition for allowance,

and claims 6, 9, 15, 22, 24, 29, and 31 overcome the stated objection because the claims depend from an allowable base claim. Accordingly, Applicant respectfully requests withdrawal of the objection to the claims.

Rejections Under 35 U.S.C. § 103

Claims 1-4, 10-13, 18-20, and 25-27 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over U.S. Patent Application Publication No. 2011/0249713, applied for by Hammarwall, *et al.* ("Hammarwall") in view of U.S. Patent Application Publication No. 2011/0034192, applied for by Lim, *et al.* ("Lim").

As noted above, independent claims 1 and 10 have been amended to incorporate features related to allowable subject matter of claim 8, and independent claims 18 and 25 have been amended to incorporate features related to allowable subject matter of claims 23 and 30, respectively. Since neither Hammarwall nor Lim discloses or suggests, whether taken alone or in any combination, all the features of the claimed subject matter, Applicant respectfully submits that independent claim 1, 10, 18, and 25, and all the claims that depend therefrom, are allowable.

Accordingly, Applicant respectfully requests withdrawal of the 35 U.S.C. § 103(a) rejection of claims 1, 10, 18, and 25. Claims 2-7, 9, 11-17, 19-22, 24, 26-29, and 31, which ultimately depend from claims 1, 10, 18, or 25, are allowable at least for this reason.

Claims 5, 7, 14, 16, 17, 21, and 28 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Hammarwall and Lim, further in view of U.S. Patent Application Publication No. 2011/0305263, applied for by Jongren, *et al.* ("Jongren").

Applicant respectfully submits that claims 1, 10, 18, and 25 are allowable over Hammarwall and Lim, and Jongren fails to cure the deficiencies of Hammarwall and Lim noted

above with regard to claims 1, 10, 18, and 25. Hence, claims 5, 7, 14, 16, 17, 21, and 28 are allowable at least because they depend from an allowable base claim.

CONCLUSION

A full and complete response has been made to the pending Office Action, and all of the stated objections and grounds for rejection have been overcome or rendered moot. Accordingly, all pending claims are allowable, and the Application is in condition for allowance.

The Examiner is invited to contact Applicant's undersigned representative at the number below if it would expedite prosecution. Prompt and favorable consideration of this Reply is respectfully requested.

Respectfully submitted,

/dongil moon/

Dongil Moon
Reg. No. L0830

Date: April 9, 2015

CUSTOMER NUMBER: 58027
H.C. Park & Associates, PLC
1894 Preston White Drive
Reston, VA 20191
Tel: 703-288-5105
Fax: 703-288-5139
HCP/DM/mkc

Electronic Acknowledgement Receipt

EFS ID:	22016204
Application Number:	13807706
International Application Number:	
Confirmation Number:	9187
Title of Invention:	TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH
First Named Inventor/Applicant Name:	Kyoungmin Park
Customer Number:	58027
Filer:	Hae-Chan Park/Dongil Moon
Filer Authorized By:	Hae-Chan Park
Attorney Docket Number:	P5158US00
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Application Type:	U.S. National Stage under 35 USC 371

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Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		P5158US00-ReplytoNFOA.pdf	257631 e6135267734c78b5ab2295a9701cfc3a1b183a1b	yes	16

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	13
	Applicant Arguments/Remarks Made in an Amendment	14	16
Warnings:			
Information:			
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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

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PTO/SB/06 (09-11)
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/807,706	Filing Date 12/28/2012	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT **04/09/2015**

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 28	Minus	** 31	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 4	Minus	***4	= 0	X $420 =	0
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	0

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/DIANIECE JACOBS/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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NOTICE OF ALLOWANCE AND FEE(S) DUE

58027 7590 05/11/2015
H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191

EXAMINER
LAM, KENNETH T

ART UNIT	PAPER NUMBER
2631	

DATE MAILED: 05/11/2015

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/807,706	12/28/2012	Kyoungmin Park	P5158US00	9187

TITLE OF INVENTION: TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	08/11/2015

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

58027 7590 05/11/2015
H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/807,706	12/28/2012	Kyoungmin Park	P5158US00	9187

TITLE OF INVENTION: TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	08/11/2015

EXAMINER	ART UNIT	CLASS-SUBCLASS
LAM, KENNETH T	2631	375-267000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ❑ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/807,706	12/28/2012	Kyoungmin Park	P5158US00	9187

58027 7590 05/11/2015

H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191

EXAMINER	
LAM, KENNETH T	

ART UNIT	PAPER NUMBER
2631	

DATE MAILED: 05/11/2015

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 13/807,706	Applicant(s) PARK, KYOUNGMIN	
	Examiner KENNETH LAM	Art Unit 2631	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *04/09/2015*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-7,9-22,24-29 and 31*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☒ All b) ☐ Some *c) ☐ None of the:
   1. ☒ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☒ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/KENNETH LAM/
Primary Examiner, Art Unit 2631

DETAILED ACTION

1. The present application is being examined under the pre-AIA first to invent provisions.

2. This office action is in response to the amendment filed on 04/09/2015. Claims 1-7, 9-22, 24-29, 31 are pending in this application and have been considered below.

Allowable Subject Matter

3. Claims 1-7, 9-22, 24-29, 31are allowed.

The following is an examiner's statement of reasons for allowance:

Claims 1 and 10 which recite the communication method of a transmitting device including a first precoder and a second precoder and the transmitting device, the prior art of record neither anticipate nor render obvious the limitation as claimed, with respect to the method comprising: determining a first bit sequence to restrict at least one precoding matrix from a first precoding matrix group, each bit of the first bit sequence corresponding to one precoding matrix of the first precoding matrix group, respectively, and the at least one precoding matrix of the first precoding matrix group being restricted from being used as a precoding matrix of the first precoder; determining a second bit sequence to restrict at least one precoding matrix from a second precoding matrix group, each bit of the second bit sequence corresponding to one precoding matrix of the second precoding matrix group, respectively, and the at least one precoding matrix of the second precoding matrix group being restricted from being used as a precoding matrix of the second precoder; and **transmitting, to a receiving device, codebook**

restricting information including at least one of the first bit sequence and the second bit sequence, receiving, from the receiving device, information relating to the precoding matrix of the first precoder and information relating to the precoding matrix of the second precoder, and wherein a period of receiving the information relating to the precoding matrix of the first precoder and a period of receiving the information relating to the precoding matrix of the second precoder are different from each other.

The prior art of record, also does not teach or suggest the communication method of a receiving device in a wireless communication system and the receiver as recited in claims 18 and 25 for the similar reason listed above.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to KENNETH LAM whose telephone number is (571)270-1862. The examiner can normally be reached on Mon - Fri 8:30 am - 5:00 pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Shuwang Liu can be reached on (571) 272-3036. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/KENNETH LAM/
Primary Examiner, Art Unit 2631

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13807706	PARK, KYOUNGMIN
	Examiner	**Art Unit**
	KENNETH LAM	2631

CPC						
Symbol					**Type**	**Version**
H04B		7	/	0456	F	2013-01-01
H04B		7	/	0413	I	2013-01-01
H04B		7	/	0626	I	2013-01-01
H04B		7	/	0469	I	2013-01-01
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CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
			/					
			/					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	28	
/KENNETH LAM/ Primary Examiner.Art Unit 2631	04/23/2015	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	4

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13807706	PARK, KYOUNGMIN
	Examiner	**Art Unit**
	KENNETH LAM	2631

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION										
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED					
375	267	H	0	4	B	7 / 02 (2006.01.01)						

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
375	260	259	295	316	

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	28	
/KENNETH LAM/ Primary Examiner.Art Unit 2631	04/23/2015	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	4

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13807706	PARK, KYOUNGMIN
	Examiner	**Art Unit**
	KENNETH LAM	2631

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	16	17												
2	2	17	18												
3	3	18	19												
4	4	19	20												
5	5	20	21												
6	6	21	22												
7	7		23												
	8	22	24												
8	9	23	25												
9	10	24	26												
10	11	25	27												
11	12	26	28												
12	13	27	29												
13	14		30												
14	15	28	31												
15	16														

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 28	
/KENNETH LAM/ Primary Examiner.Art Unit 2631 (Primary Examiner)	04/23/2015 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 4

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	42	((Kyoungmin) near2 (Park)).INV.	US-PGPUB; USPAT	AND	ON	2014/05/23 09:08
S2	611	second with prec?d$4 with codebook	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/23 09:08
S3	4	S1 S2	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/23 09:08
S4	2	"20120275314"	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/23 10:28
S5	536	restrict$4 with codebook	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/23 10:29
S6	11727	prec?d$4 near3 matrix	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/23 10:29
S7	265	S5 S6	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/23 10:29
S8	338	CSI and (first near2 prec?d$4) and (second near2 prec?d$4)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/23 10:30
S10	5	"12194640"	US-PGPUB; USPAT; FPRS; EPO; JPO;	AND	ON	2014/05/23 12:46

			DERWENT			
S11	537	restrict$4 with codebook	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:15
S12	11757	prec?d$4 near3 matrix	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:15
S13	266	S11 S12	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:15
S14	339	CSI and (first near2 prec?d$4) and (second near2 prec?d$4)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:15
S15	37	S13 S14	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:15
S16	18774	((H04B7/0639 OR H04B7/0456 OR H04B7/0469 OR H04B7/0634 OR H04B7/0413 OR H04B7/0452 OR H04B7/0626).CPC.)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:20
S17	234	S11 S16	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:21
S18	33	S14 S17	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 10:21
S19	70	restrict$4 same prec?d$4 same layer same codebook	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 11:00
S20	46	S16 S19	US-PGPUB; USPAT; FPRS; EPO; JPO;	AND	ON	2014/05/27 11:00

			DERWENT			
S21	339	CSI and (first near2 prec?d$4) and (second near2 prec?d$4)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:05
S22	70	restrict$4 same codebook same layer same prec?d$4	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:06
S23	12	S21 S22	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:06
S24	57	restrict$4 same codebook same first same second same prec?d$4	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:07
S25	16	S21 S24	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:07
S26	8541	(first near2 prec?d$4) and (second near2 prec?d$4)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:20
S27	12	S21 S22 S26	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:20
S28	280	(first near2 prec?der) and (second near2 prec?der)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:21
S29	5	S22 S28	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:21
S30	32	("20030143961" | "20040052314" | "20040192398" | "20050124393" | "20050250532" | "20060067277" | "20060292990" | "20070093281" | "20070211813" | "20070232370" |	US-PGPUB; USPAT; USOCR	AND	ON	2014/05/27 14:24

		"20070255558" | "20080001915" | "20080080449" | "20080165876" | "20080274753" | "20080298482" | "20090122884" | "20100023898" | "20100034312" | "20100035627" | "20100046650" | "20100157924" | "20100208838" | "20100220801" | "20100322176" | "20110051834" | "20110080969" | "20110216840" | "7649831" | "7822140" | "7885211" | "8284849").PN. OR ("8509338").URPN.				
S31	537	restrict$4 with codebook	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:27
S32	17	S28 S31	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:27
S33	319	restrict$4 same codebook same prec?d$4	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:38
S34	20	S28 S33	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:38
S35	114	rank with restrict$4 same codebook	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:55
S36	16	S21 S35	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:55
S37	2	"13104644"	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 14:56
S38	1239	restrict$4 with rank	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 15:00
S39	17	S28 S38	US-PGPUB;	AND	ON	2014/05/27 15:01

			USPAT; FPRS; EPO; JPO; DERWENT			
S40	3681	channel near2 status near2 information	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 15:10
S41	9	S33 S38 S40	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 15:10
S42	17	S33 S40	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 15:12
S43	3	S22 S40	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/27 15:18
S44	3	(("20100048233") or ("20110116563") or ("20090257383")).PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/05/27 17:19
S45	180	first near2 prec?d$4 with gain	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/28 09:21
S46	613	second near2 prec?d$4 with phase	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/28 09:21
S47	5	S45 S46	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/28 09:21
S48	857	(prec?d$4 with gain) and (prec?d$4 with phase)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/28 09:22
S49	537	restrict$4 with codebook	US-PGPUB; USPAT; FPRS;	AND	ON	2014/05/28 09:22

			EPO; JPO; DERWENT			
S50	37	S48 S49	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/28 09:22
S51	15	pmi and csi and S50	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/28 09:23
S52	66	pmi and csi and S48	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/05/28 09:27
S53	1	("20100142633").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2014/09/11 10:55
S54	12	(US-20100048148-$ or US-20110034192-$ or US-20110274188-$ or US-20100322176-$ or US-20110249713-$ or US-20100303034-$ or US-20110249637-$ or US-20120003945-$ or US-20120127948-$ or US-20110206024-$ or US-20110268068-$ or US-20110305263-$).did.	US-PGPUB	AND	ON	2014/09/11 11:30
S55	11372	prec?ding near2 matrix	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/09/11 11:31
S56	9	S54 S55	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2014/09/11 11:31
S57	52	((Kyoungmin) near2 (Park)).INV.	US-PGPUB; USPAT	AND	ON	2015/04/22 11:59
S58	678	restrict$4 with codebook	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2015/04/22 11:59
S59	15209	prec?d$4 near3 matrix	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2015/04/22 11:59
S60	1	S57 S58 S59	US-	AND	ON	2015/04/22

			PGPUB; USPAT; FPRS; EPO; JPO; DERWENT			11:59
S61	25184	((H04B7/0639 OR H04B7/0456 OR H04B7/0469 OR H04B7/0634 OR H04B7/0413 OR H04B7/0452 OR H04B7/0626).CPC.)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2015/04/22 12:00
S62	287	S58 S59 S61	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2015/04/22 12:01
S63	287	period with precod$4 with matrix	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2015/04/22 12:01
S64	11	S62 S63	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2015/04/22 12:01
S76	25184	((H04B7/0639 OR H04B7/0456 OR H04B7/0469 OR H04B7/0634 OR H04B7/0413 OR H04B7/0452 OR H04B7/0626).CPC.)	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2015/04/22 14:49
S77	678	restrict$4 with codebook	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2015/04/22 14:50
S78	15209	prec?d$4 near3 matrix	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2015/04/22 14:50
S79	381	S77 S78	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2015/04/22 14:50
S80	287	S76 S79	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2015/04/22 14:50
S82	86	period with prec?d$4 with matrix with	US-	AND	ON	2015/04/22

		receiv$4	PGPUB; USPAT; FPRS; EPO; JPO; DERWENT			14:51
S83	1	S80 S82	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2015/04/22 14:52
S84	2	period with precoder with matrix with receiv$4	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2015/04/22 14:52
S85	16	period with precoder with matrix	US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT	AND	ON	2015/04/22 14:53

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S65	7313	((H04B7/0639 OR H04B7/0456 OR H04B7/0469 OR H04B7/0634 OR H04B7/0413 OR H04B7/0452 OR H04B7/0626).CPC.)	US-PGPUB; USPAT; UPAD	AND	ON	2015/04/22 11:23
S66	143	rank with restrict$4 same codebook	US-PGPUB; USPAT; UPAD	AND	ON	2015/04/22 11:31
S67	241	period with precod$4 with matrix	US-PGPUB; USPAT; UPAD	AND	ON	2015/04/22 11:32
S68	0	S65 S66 S67	US-PGPUB; USPAT; UPAD	AND	ON	2015/04/22 11:32
S69	132	S65 S67	US-PGPUB; USPAT; UPAD	AND	ON	2015/04/22 11:32
S70	575	restrict$4 with codebook	US-PGPUB; USPAT; UPAD	AND	ON	2015/04/22 11:32
S71	10	S69 S70	US-PGPUB; USPAT; UPAD	AND	ON	2015/04/22 11:32
S72	893	(prec?d$4 with gain) and (prec?d$4 with phase)	US-PGPUB; USPAT; UPAD	AND	ON	2015/04/22 11:43

S73	1355	restrict$4 with rank	US-PGPUB; USPAT; UPAD	AND	ON	2015/04/22 11:43
S74	9	S65 S72 S73	US-PGPUB; USPAT; UPAD	AND	ON	2015/04/22 11:43
S75	5	S65 S67 S73	US-PGPUB; USPAT; UPAD	AND	ON	2015/04/22 11:44

4/ 23/ 2015 9:14:34 AM
C:\ Users\ klam1\ Documents\ EAST\ Workspaces\ 13807706.wsp

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13807706	PARK, KYOUNGMIN
	Examiner	Art Unit
	KENNETH LAM	2631

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	05/28/2014	09/11/2014	01/05/2015	04/23/2015					
1	1	✓	✓	✓	=					
2	2	✓	✓	✓	=					
3	3	✓	✓	✓	=					
4	4	✓	✓	✓	=					
5	5	✓	✓	✓	=					
6	6	O	O	O	=					
7	7	✓	✓	✓	=					
	8	O	O	O	-					
8	9	O	O	O	=					
9	10	✓	✓	✓	=					
10	11	✓	✓	✓	=					
11	12	✓	✓	✓	=					
12	13	✓	✓	✓	=					
13	14	✓	✓	✓	=					
14	15	O	O	O	=					
15	16	✓	✓	✓	=					
16	17	✓	✓	✓	=					
17	18	✓	✓	✓	=					
18	19	✓	✓	✓	=					
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20	21	✓	✓	✓	=					
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22	24	O	O	O	=					
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25	27	✓	✓	✓	=					
26	28	✓	✓	✓	=					
27	29	O	O	O	=					
	30	O	O	O	-					
28	31	O	O	O	=					

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13807706	PARK, KYOUNGMIN
	Examiner	Art Unit
	KENNETH LAM	2631

CPC- SEARCHED		
Symbol	Date	Examiner
H04B7/0639 OR H04B7/0456 OR H04B7/0469 OR H04B7/0634 OR H04B7/0413 OR H04B7/0452 OR H04B7/0626	4/23/2015	KL

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES		
Search Notes	Date	Examiner
inventor search	5/28/2014	KL
EAST search	5/28/2014	KL
CPC search	5/28/2014	KL
inventor search	4/23/2015	KL
EAST search	4/23/2015	KL
CPC search with keywords	4/23/2015	KL
interference search	4/23/2015	KL

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

	/KENNETH LAM/ Primary Examiner.Art Unit 2631

INTERFERENCE SEARCH			
US Class/ CPC Symbol	**US Subclass / CPC Group**	**Date**	**Examiner**
H04B7/0639 OR H04B7/0456 OR H04B7/0469 OR H04B7/0634 OR H04B7/0413 OR H04B7/0452 OR H04B7/0626		4/23/2015	KL

	/KENNETH LAM/ Primary Examiner.Art Unit 2631

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

H.C. Park & Associates, PLC
1894 Preston White Drive
Reston, VA 20191

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/807,706	2012-12-28	Kyoungmin PARK	P5158US00	9187

TITLE OF INVENTION:

TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
NONPROVISIONAL	UNDISCOUNTED	$960	$0	$0	$960	2015-08-11

EXAMINER	ART UNIT	CLASS-SUBCLASS
LAM, KENNETH T	2631	375-267000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 H.C. Park & Associates, PLC
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE	(B) RESIDENCE: (CITY and STATE OR COUNTRY)
Pantech Co., Ltd.	Seoul, Republic of Korea

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☑ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:

☑ Issue Fee

☐ Publication Fee (No small entity discount permitted)

☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

☐ A check is enclosed.

☑ Payment by credit card. Form PTO-2038 is attached.

☑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 50-3698 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature /dongil moon/ Date 2015-08-07

Typed or printed name Dongil Moon Registration No. L0830

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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The information provided by you in this form will be subject to the following routine uses:

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	13807706
Filing Date:	28-Dec-2012
Title of Invention:	TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH
First Named Inventor/Applicant Name:	Kyoungmin Park
Filer:	Hae-Chan Park/Thomas Traub
Attorney Docket Number:	P5158US00

Filed as Large Entity

Filing Fees for U.S. National Stage under 35 USC 371

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl Issue Fee	1501	1	960	960

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**960**

Electronic Acknowledgement Receipt

EFS ID:	23146750
Application Number:	13807706
International Application Number:	
Confirmation Number:	9187
Title of Invention:	TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH
First Named Inventor/Applicant Name:	Kyoungmin Park
Customer Number:	58027
Filer:	Hae-Chan Park/Christopher Kilner
Filer Authorized By:	Hae-Chan Park
Attorney Docket Number:	P5158US00
Receipt Date:	07-AUG-2015
Filing Date:	28-DEC-2012
Time Stamp:	17:36:38
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$960
RAM confirmation Number	3939
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	P5158US00-ISsueFee.pdf	1868145 cfe69769a9db6b6b33b413f3ccc8b2f78befa66c	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30947 ffb7d028c847e180298a83b88e7137be8851542a	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	1899092		

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Notice of References Cited	Application/Control No. 13/807,706	Applicant(s)/Patent Under Reexamination PARK, KYOUNGMIN	
	Examiner KENNETH LAM	Art Unit 2631	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2011/0249713	10-2011	Hammarwall et al.	375/220
*	B	US-2011/0034192	02-2011	Lim et al.	455/501
*	C	US-2011/0305263	12-2011	~~J+e et al.~~ J+e,uml O+ee NGREN et al.	375/219
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

Change(s) applied to document, /S.X.R./ 5/29/2015

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
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	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Notice of References Cited	Application/Control No. 13/807,706	Applicant(s)/Patent Under Reexamination PARK, KYOUNGMIN	
	Examiner KENNETH LAM	Art Unit 2631	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2011/0249713	10-2011	Hammarwall et al.	375/220
*	B	US-2011/0305263	12-2011	~~Jie et al.~~ Jongren et al.	375/219
*	C	US-2011/0034192	02-2011	Lim et al.	455/501
*	D	US-2012/0003945	01-2012	Liu et al.	455/115.1
*	E	US-2010/0322176	12-2010	Chen et al.	370/329
*	F	US-2011/0032839	02-2011	Chen et al.	370/252
*	G	US-2011/0274188	11-2011	Sayana et al.	375/260
*	H	US-2012/0127948	05-2012	Chung et al.	370/329
*	I	US-2011/0206024	08-2011	LEE et al.	370/338
*	J	US-2011/0268068	11-2011	Jian et al.	370/329
	K	US-			
	L	US-			
	M	US-			

Change(s) applied to document, /S.X.R./ 5/29/2015

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Notice of References Cited	Application/Control No. 13/807,706	Applicant(s)/Patent Under Reexamination PARK, KYOUNGMIN	
	Examiner KENNETH LAM	Art Unit 2631	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2011/0305263	12-2011	~~J+e et al.~~ J+e,uml O+ee NGREN et al.	375/219
*	B	US-2011/0034192	02-2011	Lim et al.	455/501
*	C	US-2011/0249713	10-2011	Hammarwall et al.	375/220
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

Change(s) applied to document, /S.X.R./ 5/29/2015

FOREIGN PATENT DOCUMENTS

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	N					
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	Q					
	R					
	S					
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Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

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www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/807,706	09/15/2015	9136924	P5158US00	9187

58027 7590 08/26/2015

H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 94 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Kyoungmin Park, Seoul, KOREA, REPUBLIC OF;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1
Stylesheet Version v1.2

EPAS ID: PAT4337887

SUBMISSION TYPE:	NEW ASSIGNMENT
NATURE OF CONVEYANCE:	ASSIGNMENT

CONVEYING PARTY DATA

Name	Execution Date
PANTECH INC	10/31/2016

RECEIVING PARTY DATA

Name:	GOLDPEAK INNOVATIONS INC
Street Address:	SUITE #806, DIGITAL-RO 34-GIL, 55, GURO-GU
City:	SEOUL
State/Country:	KOREA, REPUBLIC OF

PROPERTY NUMBERS Total: 61

Property Type	Number
Patent Number:	7894330
Patent Number:	8102804
Patent Number:	7505775
Patent Number:	7725796
Patent Number:	8873519
Patent Number:	9313743
Patent Number:	8848674
Patent Number:	8649346
Patent Number:	9237566
Patent Number:	9008046
Patent Number:	8780860
Patent Number:	9054835
Patent Number:	9077510
Patent Number:	8538411
Patent Number:	9025485
Patent Number:	9088396
Patent Number:	9136924
Patent Number:	8787216
Patent Number:	8837452
Patent Number:	8811518
Patent Number:	9319252

Property Type	Number
Patent Number:	9088992
Patent Number:	8917619
Patent Number:	9191833
Patent Number:	9386600
Patent Number:	8964520
Patent Number:	7660404
Patent Number:	6809641
Patent Number:	8311519
Patent Number:	7260419
Patent Number:	RE43789
Patent Number:	7693558
Patent Number:	8200899
Patent Number:	7567530
Patent Number:	7599487
Patent Number:	7409225
Patent Number:	7136671
Patent Number:	8374572
Patent Number:	8090405
Patent Number:	8060114
Patent Number:	7151487
Patent Number:	7006037
Patent Number:	8319799
Patent Number:	8054846
Patent Number:	7102196
Patent Number:	6801271
Patent Number:	6925313
Patent Number:	8270999
Patent Number:	8433367
Patent Number:	7283839
Patent Number:	6557010
Patent Number:	7103387
Patent Number:	7925242
Patent Number:	7475332
Patent Number:	8331920
Patent Number:	7636845
Patent Number:	8078145
Application Number:	14368224
Application Number:	14356218

Property Type	Number
Application Number:	14348840
Application Number:	14394248

CORRESPONDENCE DATA

Fax Number:

Correspondence will be sent to the e-mail address first; if that is unsuccessful, it will be sent using a fax number, if provided; if that is unsuccessful, it will be sent via US Mail.

Phone: 5717304574

Email: edward.park@fidelis-laws.com

Correspondent Name: FIDELIS LAW GROUP, PLLC

Address Line 1: 444 W BROAD ST UNIT 426

Address Line 4: FALLS CHURCH, VIRGINIA 22046

NAME OF SUBMITTER:	EDWARD PARK
SIGNATURE:	/sjp/
DATE SIGNED:	03/27/2017
	This document serves as an Oath/Declaration (37 CFR 1.63).

Total Attachments: 4

source=Patent Assignment Agreement_2016.11 executed_Redacted#page1.tif

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PATENT ASSIGNMENT

This Patent Assignment (the "Assignment") is made from **PANTECH INC** ("Assignor"), a corporation organized and existing under the laws of Korea with its principal place at Pantech Building, 179 Seongam-ro Mapo-go, Seoul, Korea, to **GoldPeak Innovations Inc** ("Assignee"), a corporation organized under the laws of the Republic of Korea, having an address at suite # 806, Digital-ro 34-gil, 55, Guro-gu, Seoul, Korea.

WHEREAS, Assignor and Assignee have entered into that certain Patent Assignment Agreement dated as of October 31, 2016 (the "Agreement"), whereby, among other things, Assignor has agreed to assign, and Assignee has agreed to accept, all of those patents and patent applications listed on Annex A hereto, and all existing and any future Patents that may be granted therefore throughout the world, all of their foreign counterparts, reissues, re-examinations, renewals, extensions, provisional, divisional and continuation applications including continuation in part, and any United States and foreign applications and patents that claimed, claim and will claim priorities to those listed above, as well as all patents and applications from which those listed above derive, relate, or claim priority (collectively, the "Patent Rights").

NOW THEREFORE, in exchange for good and valuable consideration under the Agreement, the receipt and sufficiency of which Assignor hereby acknowledges, and as a condition to Assignee entering into the Agreement, Assignor hereby assigns and transfers to Assignee and Assignee accepts, all of the right, title and interest of Assignor throughout the world in and to any and all inventions claimed or disclosed in the Patent Rights.

This Assignment includes all of Assignor's right, title and interest in, to and under each of the Patent Rights (including without limitation, rights to damages and payments for past, present and future infringements or misappropriations, including the right to collect and receive any royalties, or settlements for such infringements, all rights to sue for injunctive or other equitable relief, and any and all causes of action relating to any of the inventions or discoveries thereof), and, as agreed to between the parties, all continuations, continuations-in-part, divisionals, substitutes, reexaminations, post-opposition foreign counterpart patents and applications, reissues and extensions thereof, if any, and, Assignor requests the Commissioner of Patents of the United States (and all foreign officials, whose duty it is to issue patents and applications as aforesaid) to record Assignee as the owner of such Patent Rights, to the same extent as held by Assignor, and to issue the Letters Patent for such Patent Rights in the name of Assignee, as assignee of the Patent Rights.

This instrument shall inure to the benefit of Assignee and its successors and assigns, and shall be binding upon Assignor and its successors and assigns.

Assignor hereby covenants that it has full right to convey the entire interest herein assigned, and that it has not executed, and will not execute, any agreement in conflict with this Assignment. Assignor hereby further covenants and agrees that it will communicate to Assignee any and all facts known to it respecting the Patent Rights, including the existing licenses, encumbrances or other restrictions that are expressly binding on successors to the Patent Rights, and testify in any

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legal proceeding, sign all lawful papers, execute and deliver all papers and take any actions that may be necessary or desirable to perfect the title to any aforementioned patents and inventions, execute all divisional, continuation, reexamination, reissue, substitute applications, and any similar and equivalent procedure under current and future legislations and regulations throughout the world, and make all rightful oaths to aid Assignee to obtain and enforce proper patent protection for said inventions in all countries.

Date of: _____

PANTECH INC.

_____
Signature

Joon CHUNG
Name

CEO
Title

GoldPeak Innovations Inc.:

_____
Signature

Youngjoon Rhee
Name

CEO
Title

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Annex A

Patents and/or Patent Applications

NO	Category	Application No	Filing Date	Patent No	Issued Date
1	[redacted]	12/388,243	2/18/2009	US 7894330	2/22/2011
2		12/347,352	12/31/2008	US 8102804	1/24/2012
3		11/165,744	6/24/2005	US 7505775	3/17/2009
4		11/320,334	12/27/2005	US 7725796	5/25/2010
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8		13/332,089	12/20/2011	US 8649346	2/11/2014
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10		14/056,474	10/17/2013	US 9008046	4/14/2015
11		13/098,056	4/29/2011	US 8780860	7/15/2014
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STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: GOLDPEAK INNOVATIONS INC

Application No./Patent No.: 13/807,706 Filed/Issue Date: 12/28/2012

Titled: TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH

GOLDPEAK INNOVATIONS INC, a corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☐ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

B. ☑ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: PARK, KYOUNGMIN To: PANTECH CO., LTD.

The document was recorded in the United States Patent and Trademark Office at
Reel 029547, Frame 0765, or for which a copy thereof is attached.

2. From: PANTECH CO., LTD. To: PANTECH INC.

The document was recorded in the United States Patent and Trademark Office at
Reel 039428, Frame 0268, or for which a copy thereof is attached.

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/96 (08-12)
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STATEMENT UNDER 37 CFR 3.73(c)

3. From: PANTECH INC. To: GOLDPEAK INNOVATIONS INC

The document was recorded in the United States Patent and Trademark Office at
Reel 042098, Frame 0451, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☐ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/jwkim/	2017-10-24
Signature	Date
Jongwon Kim	66993
Printed or Typed Name	Title or Registration Number

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

[x] Practitioners associated with Customer Number: 66390

OR

[ ] Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignment documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

[x] The address associated with Customer Number: 66390

OR

[ ]

Firm or individual name		
Address		
City	State	Zip
Country		
Telephone	Email	

Assignee name and address: GOLDPEAK INNOVATIONS INC.
Suite # 808, Digital-ro 34-gil, 55,Guro-gu, Seoul, 08378, South Korea(Republic of Korea)

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of the practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee.

Signature	Date 17 / 10 / 2017
Name Youngjoon Rhee	Telephone +82-10-8929-1905
Title CEO at GOLDPEAK INNOVATIONS INC	

This collection of information is required by 37 CFR 1.31, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public, which is to update (and by the USPTO to process) the file of a patent or reexamination proceeding. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 18 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt

EFS ID:	30741840
Application Number:	13807706
International Application Number:	
Confirmation Number:	9187
Title of Invention:	TRANSMITTING DEVICE AND A METHOD OF COMMUNICATING THEREWITH, AND RECEIVING DEVICE AND A METHOD OF COMMUNICATING THEREWITH
First Named Inventor/Applicant Name:	Kyoungmin Park
Customer Number:	58027
Filer:	Jongwon Kim
Filer Authorized By:	
Attorney Docket Number:	P5158US00
Receipt Date:	24-OCT-2017
Filing Date:	28-DEC-2012
Time Stamp:	13:07:02
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	13807706-9187.pdf	1935084 1c93f77b753f950874af0ed787d07a431982bbea	no	3
Warnings:					

Information:					
2	Power of Attorney	80_sb_GPOA_GoldPeak.pdf	684881 66f5127db48c2b8b41fad91bdf748c3f97e394eb	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	2619965	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/807,706	12/28/2012	Kyoungmin Park	P5158US00

CONFIRMATION NO. 9187

POWER OF ATTORNEY NOTICE

58027
H.C. PARK & ASSOCIATES, PLC
1894 PRESTON WHITE DRIVE
RESTON, VA 20191

OC00000095089757

Date Mailed: 10/30/2017

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/24/2017.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/tlulu/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/807,706	12/28/2012	Kyoungmin Park	P5158US00

CONFIRMATION NO. 9187

66390
LEX IP MEISTER, PLLC
5180 PARKSTONE DRIVE, SUITE 175
CHANTILLY, VA 20151

POA ACCEPTANCE LETTER

OC00000095089767

Date Mailed: 10/30/2017

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/24/2017.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/tlulu/

PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1
Stylesheet Version v1.2

EPAS ID: PAT6105570

SUBMISSION TYPE:	NEW ASSIGNMENT
NATURE OF CONVEYANCE:	ASSIGNMENT

CONVEYING PARTY DATA

Name	Execution Date
GOLDPEAK INNOVATIONS INC	05/07/2020

RECEIVING PARTY DATA

Name:	PANTECH CORPORATION
Street Address:	8 YANGJAECHEONRO-21GIL, SUITE 402, SEOCHO-GU,
City:	SEOUL
State/Country:	KOREA, REPUBLIC OF
Postal Code:	06748

PROPERTY NUMBERS Total: 234

Property Type	Number
Patent Number:	10014988
Patent Number:	9548839
Patent Number:	9048991
Patent Number:	8631297
Patent Number:	8631298
Patent Number:	8681599
Patent Number:	7894330
Patent Number:	9750054
Patent Number:	9288824
Patent Number:	10057925
Patent Number:	8611297
Patent Number:	8102804
Patent Number:	8380227
Patent Number:	8583147
Patent Number:	9357486
Patent Number:	8606303
Patent Number:	7505776
Patent Number:	7505775
Patent Number:	7853852
Patent Number:	7725796

Property Type	Number
Patent Number:	9838194
Patent Number:	9270365
Patent Number:	8873519
Patent Number:	9713095
Patent Number:	10045304
Patent Number:	9313743
Patent Number:	10609650
Patent Number:	9680590
Patent Number:	9419739
Patent Number:	8649346
Patent Number:	9860046
Patent Number:	9485072
Patent Number:	9237566
Patent Number:	9008046
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Patent Number:	8780860
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Patent Number:	9392582
Patent Number:	9131482
Patent Number:	9265034
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Patent Number:	9025485
Patent Number:	9742542
Patent Number:	9369251
Patent Number:	9088396
Patent Number:	8897182
Patent Number:	9136924
Patent Number:	9948440
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Patent Number:	8787216
Patent Number:	9893866
Patent Number:	9380581
Patent Number:	8837452
Patent Number:	8576822

Property Type	Number
Patent Number:	10567140
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Patent Number:	9825686
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Patent Number:	10153821
Patent Number:	10057940
Patent Number:	9474025
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Patent Number:	9374213
Patent Number:	8917619
Patent Number:	9955376
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Patent Number:	7260419
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Patent Number:	RE43789
Patent Number:	RE42996
Patent Number:	7292561
Patent Number:	9661113
Patent Number:	8433379
Patent Number:	7693558
Patent Number:	8200899
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Patent Number:	7136671
Patent Number:	9729699
Patent Number:	9178982
Patent Number:	8699987

Property Type	Number
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Patent Number:	10158752
Patent Number:	7643815
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Patent Number:	7668553
Patent Number:	7151487
Patent Number:	6784829
Patent Number:	7006037
Patent Number:	9495730
Patent Number:	8767018
Patent Number:	8319799
Patent Number:	8120626
Patent Number:	7755647
Patent Number:	8446915
Patent Number:	8054846
Patent Number:	7693163
Patent Number:	7102196
Patent Number:	6801271
Patent Number:	6925313
Patent Number:	8270999
Patent Number:	7660592
Patent Number:	9204118
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Patent Number:	7668569
Patent Number:	7412262
Patent Number:	7283839
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Patent Number:	7103387
Patent Number:	9839000
Patent Number:	9319507
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Patent Number:	8532626
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Patent Number:	7420566
Patent Number:	7475332
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Patent Number:	8331920

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Patent Number:	7636845
Patent Number:	8565724
Patent Number:	8078145
Patent Number:	7386297
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Patent Number:	9300805
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Patent Number:	9256747
Patent Number:	9575631
Patent Number:	9250957
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Patent Number:	10282054
Patent Number:	9930499
Patent Number:	9503559
Patent Number:	9113312
Patent Number:	8634818
Patent Number:	10225697
Patent Number:	8332706

Property Type	Number
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Patent Number:	8433350
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Patent Number:	9167534
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Patent Number:	7577115
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Application Number:	15997919
Application Number:	16394702
Application Number:	16392323
Application Number:	15820980
Application Number:	16418708
Application Number:	16272473
Application Number:	16387174
Application Number:	15911518
Application Number:	16203319
Application Number:	16275039
Application Number:	16288278

Property Type	Number
Application Number:	14061316
Application Number:	16287787
Application Number:	15801433
Application Number:	16227369
Application Number:	15705131
Application Number:	16685738
Application Number:	15017133
Application Number:	16405803
Application Number:	16290914
Application Number:	12958749
Application Number:	16452244
Application Number:	16826013
Application Number:	16733106
Application Number:	16819625
Application Number:	16813676
Application Number:	16823170
Application Number:	16806830
Application Number:	16730711
Application Number:	16711269
Application Number:	16806665
Application Number:	16826054
Application Number:	16037067
Application Number:	16184560
Application Number:	16694830

CORRESPONDENCE DATA

Fax Number: (703)643-9789

Correspondence will be sent to the e-mail address first; if that is unsuccessful, it will be sent using a fax number, if provided; if that is unsuccessful, it will be sent via US Mail.

Phone: 4349062975
Email: yoon@capitoliplaw.com
Correspondent Name: YEASUN YOON
Address Line 1: 20319 KIAWAH ISLAND DR
Address Line 4: ASHBURN, VIRGINIA 20147

ATTORNEY DOCKET NUMBER:	PA01GOLDPEAKTOPANTECHCORP
NAME OF SUBMITTER:	YEASUN YOON
SIGNATURE:	/yoon/
DATE SIGNED:	05/13/2020
	This document serves as an Oath/Declaration (37 CFR 1.63).

Total Attachments: 17
source=Goldpeak Patent Assignment_20200507_actual sign#page1.tif
source=Goldpeak Patent Assignment_20200507_actual sign#page2.tif
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CONFIRMATORY ASSIGNMENT OF PATENT RIGHTS

This CONFIRMATORY ASSIGNMENT OF PATENT RIGHTS (this "**Assignment**") is made this ____ day of April 2020, by **GoldPeak Innovations Inc,** a Korean company ("**Assignor**"), in favor of **Pantech Corporation.**, a Korean company ("**Assignee**").

WHEREAS, Assignor and Assignee are party to that certain Patent Sale and Purchase Agreement of even date herewith (as in effect from time to time, the "**Patent Sale and Purchase Agreement**"); capitalized terms used but not otherwise defined in this Assignment shall have the respective meaning assigned thereto in the Patent Sale and Purchase Agreement; and

WHEREAS, pursuant to the Patent Sale and Purchase Agreement, Assignor has agreed to sell, convey, transfer, assign and deliver to Assignee all right, title and interest, including, without limitation, Patent Rights, in and to the patents, provisional patent applications, and patent applications listed on listed on Schedule A hereto (collectively, the "**Patents**").

NOW, THEREFORE, for good and valuable consideration, receipt of which is hereby acknowledged by Assignor, Assignor hereby sells, conveys, transfers, and assigns to Assignee, its successors, legal representatives and assigns all right, title and interest in the United States and throughout the world in and to:

The Patents and any and all letters patent that are or may be granted thereon, and any legal equivalent and counterpart thereof that may be granted in any country or countries foreign to the United States, in each case including without limitation any extensions, substitutes, continuations, continuations-in-part, divisions, reissues, reexaminations, and renewals thereof, or other equivalents thereof, and further, all rights and privileges pertaining to the Patents and any and all letters patent that are or may be granted thereon, and any legal equivalent thereof that may be granted in any country or countries foreign to the United States as well as all inventions, invention disclosures, and discoveries described in any of the foregoing and including, without limitation, the right, if any, to petition, sue or otherwise seek and recover damages, profits and any other remedy (monetary, injunctive, declaratory or other relief or remedy of any kind) in the United States and anywhere throughout the world for any past, present and future infringement thereof, conversion or misappropriation of, or other injury, offense, violation, breach of duty or wrong relating to, any of the Patents, or any license, agreement, contract or other matter relating thereto.

Assignor hereby authorizes and requests the Commissioner of Patents and Trademarks of the United States of America and the appropriate officers of all other jurisdictions in which the Patents are or may be registered or in which applications included among the Patents are pending, to record the title of Assignee, its successors, legal representatives and assigns, as owner of all right, title and interest in and to the Patents, and to issue to Assignee, its successors, legal representatives and assigns, all letters patent and any legal equivalent thereof that may be granted in any country or countries foreign to the United States and recordations of patent rights resulting from any application included among the Patents, according to this instrument.

Except to the extent that federal law preempts state law with respect to the matters covered hereby, this Assignment shall be governed by and construed in accordance with the laws of the State of Delaware, without giving effect to any of the principles of conflicts of laws thereof that would result in the application of the laws of another jurisdiction to this Assignment.

This Assignment will inure to the benefit of Assignee, its successors, assigns, and other legal representatives and will be binding upon Assignor, its successors, assigns, and other legal representatives.

Assignor has the full power and authority, and has obtained all Third Party consents, approvals and/or other authorizations required to enter into this Assignment and to carry out its obligations hereunder.

If Assignee is unable for any reason to secure Assignor's or its affiliates or their respective successors' or assigns' signature to any document it is entitled to under this Assignment, Assignor and its affiliates hereby irrevocably designate and appoint Assignee, and Assignee's duly authorized officers, agents and representatives, as its agents and attorneys-in-fact, coupled with an interest, with full power of substitution to act for and on the behalf and instead of Assignor, to execute and file any such document or documents and to do all other lawfully permitted acts to further the purposes of this Assignment with the same legal force and effect as if executed by Assignor.

IN WITNESS WHEREOF, Assignor has caused this Assignment to be executed by its duly authorized officer, as of the date first written above.

ASSIGNOR:

GoldPeak Innovations Inc.

By: Saekyung Park

Name: Saekyung Park

Title: CEO

Schedule A

Family	Country	Application #	Application Date	Issued #	Issued Date
1	U.S.A.	2017-406403	1/13/2017	10014988	7/3/2018
	U.S.A.	15/997,919	6/5/2018	Pending	
	U.S.A.	2015-726014	5/29/2015	9548839	1/17/2017
	U.S.A.	2014-184345	2/19/2014	9048991	6/2/2015
	U.S.A.	2013-750669	1/25/2013	8631297	1/14/2014
	U.S.A.	2012-750953	1/25/2013	8631298	1/14/2014
	U.S.A.	2011-012702	1/24/2011	8681599	3/25/2014
	U.S.A.	2009-388243	2/18/2009	7894330	2/22/2011
	TAIWAN	98105169	2/18/2009	I422201	1/1/2014
	SWEDEN	13170420.7	6/4/2013	2637348	6/24/2015
	NETHERLAND	13170420.7	2/18/2009	2637348	6/24/2015
	JAPAN	2016-215172	11/2/2016	6401224	9/14/2018
	JAPAN	2015-020714	2/4/2015	6038974	11/11/2016
	JAPAN	2013-221358	10/24/2013	5694479	2/13/2015
	JAPAN	2012-037585	2/23/2012	5400186	11/1/2013
	JAPAN	2009-554464	2/13/2009	4982653	5/11/2012
	ITALY	09 153 111.1	2/18/2009	2093924	8/14/2013
	U.K.	13170420.7	2/18/2009	2637348	6/24/2015
	E.P.O	09 153 111.1	2/18/2009	2093924	8/14/2013
	U.K.	09 153 111.1	2/18/2009	2093924	8/14/2013
	FRANCE	13170420.7	2/18/2009	2637348	6/24/2015
	FRANCE	09 153 111.1	2/18/2009	2093924	8/14/2013
	E.P.O	13170420.7	2/18/2009	2637348	6/24/2015
	FINLAND	13170420.7	6/4/2013	2637348	6/24/2015
	E.P.O	15166204.6	5/4/2015	2922233	11/22/2017
	GERMANY	15166204.6	11/13/2017	2922233	11/22/2017
	U.K.	15166204.6	11/13/2017	2922233	11/22/2017
	FRANCE	15166204.6	11/13/2017	2922233	11/22/2017
	GERMANY	09 153 111.1	2/18/2009	2093924	8/14/2013
	GERMANY	13170420.7	2/18/2009	2637348	6/24/2015
	CHINA	201310194226.5	5/23/2013	103354491	8/24/2016
	CHINA	200980000075.7	2/13/2009	101682489	7/24/2013
	CANADA	2715941	2/13/2009	2715941	4/11/2017
	AUSTRALIA	2009332929	2/13/2009	2009332929	11/14/2013
	KR	1020080124084	12/8/2008	925439	10/30/2009
2	U.S.A.	2016-069340	3/14/2016	9750054	8/29/2017

	U.S.A.	2013-960448	8/6/2013	9288824	3/15/2016
	U.S.A.	15/690,042	8/29/2017	10057925	8/21/2018
	U.S.A.	13/340447	12/29/2011	8611297	12/17/2013
	U.S.A.	2008-347352	12/31/2008	8102804	1/24/2012
	E.P.O	08866014	12/31/2008	2227923	7/29/2015
	SWEDEN	08866014	7/1/2010	2227923	7/29/2015
	NETHERLAND	08866014	7/1/2010	2227923	7/29/2015
	U.K.	08866014	7/1/2010	2227923	7/29/2015
	FRANCE	08866014	7/1/2010	2227923	7/29/2015
	FINLAND	08866014	7/1/2010	2227923	7/29/2015
	GERMANY	08866014	7/1/2010	2227923	7/29/2015
	CHINA	201410265062.5	6/13/2014	103997794	1/15/2019
	CHINA	200880127735	8/31/2010	101960906	4/20/2016
	KR	1020150011228	1/23/2015	1540418	7/23/2015
	KR	1020080047656	5/22/2008	1519345	5/6/2015
3	U.S.A.	12/398084	3/4/2009	8380227	2/19/2013
	U.S.A.	12/398072	3/4/2009	8583147	11/12/2013
	U.S.A.	2013-091916	11/27/2013	9357486	5/31/2016
	U.S.A.	12/371526	2/13/2009	8606303	12/10/2013
	U.S.A.	11/691410	3/26/2007	7505776	3/17/2009
	U.S.A.	11/165744	6/24/2005	7505775	3/17/2009
	TURKEY	05756764.6	1/12/2007	1767036	10/31/2012
	SLOVENIA	05756764.6	1/12/2007	1767036	10/31/2012
	SWEDEN	05756764.6	1/12/2007	1767036	10/31/2012
	RUMANIA	05756764.6	1/12/2007	1767036	10/31/2012
	PORTUGAL	05756764.6	1/12/2007	1767036	10/31/2012
	POLAND	05756764.6	1/12/2007	1767036	10/31/2012
	NETHERLAND	05756764.6	1/12/2007	1767036	10/31/2012
	MEXICO	PA/a/2006/014980	12/19/2006	263607	1/8/2009
	MONACO	05756764.6	1/12/2007	1767036	10/31/2012
	Luxembourg	05756764.6	1/12/2007	1767036	10/31/2012
	LITHUANIA	05756764.6	1/12/2007	1767036	10/31/2012
	JAPAN	2007-517968	12/20/2006	4654241	12/24/2010
	ITALY	05756764.6	1/12/2007	1767036	10/31/2012
	INDIA	0713/DELNP/2007	1/25/2007	296968	5/22/2018
	ISRAEL	180227	12/21/2006	180227	12/28/2011
	ICELAND	05756764.6	6/25/2005	1767036	10/31/2012
	IRELAND	05756764.6	1/12/2007	1767036	10/31/2012
	HUNGARY	05756764.6	1/12/2007	1767036	10/31/2012
	GREECE	05756764.6	1/12/2007	1767036	10/31/2012

	U.K.	05756764.6	1/12/2007	1767036	10/31/2012
	SLOVAKIA	05756764.6	6/25/2005	1767036	10/31/2012
	FRANCE	05756764.6	1/12/2007	1767036	10/31/2012
	SWITZERLAND	5756764.6	6/25/2005	1767036	10/31/2012
	FINLAND	05756764.6	1/12/2007	1767036	10/31/2012
	SPAIN	05756764.6	1/12/2007	1767036	10/31/2012
	E.P.O	12189742	10/24/2012	2552164	9/5/2018
	GERMANY	12189742.5	8/28/2018	2552164	9/5/2018
	FRANCE	12189742.5	8/28/2018	2552164	9/5/2018
	U.K.	12189742.5	8/28/2018	2552164	9/5/2018
	E.P.O	05756764.6	6/25/2005	1767036	10/31/2012
	ESTONIA	05756764.6	1/12/2007	1767036	10/31/2012
	DENMARK	05756764.6	1/12/2007	1767036	10/31/2012
	GERMANY	05756764.6	1/12/2007	1767036	10/31/2012
	CZ	05756764.6	1/12/2007	1767036	10/31/2012
	CYPRUS	05756764.6	1/12/2007	CY20131100062 - EP1767036	10/31/2012
	CHINA	200910224551.5	11/17/2009	ZL200910224551.5	12/7/2016
	CHINA	200580020940.6	12/25/2006	ZL 2005 8 0020940.6	3/24/2010
	CANADA	2569425	12/1/2006	2569425	6/3/2014
	BULGARIA	05756764.6	1/12/2007	1767036	10/31/2012
	Belgium	05756764.6	1/12/2007	1767036	10/31/2012
	AUSTRALIA	2005257642	11/24/2006	2005257642	11/12/2009
	AUSTRIA	05756764.6	1/12/2007	1767036	10/31/2012
	KR	1020050019211	3/8/2005	875419	12/16/2008
	KR	1020090013393	2/18/2009	935294	12/24/2009
	KR	1020040077649	9/25/2004	908260	7/10/2009
4	U.S.A.	12/684847	1/8/2010	7853852	12/14/2010
	U.S.A.	11/320374	12/27/2005	7725796	5/25/2010
	TAIWAN	94146828	12/27/2005	I416897	11/21/2013
	MEXICO	MX/a/2007/007796	6/25/2007	270303	9/23/2009
	JAPAN	2013-236045	11/14/2013	5619262	9/26/2014
	JAPAN	2012-142491	6/25/2012	5554375	6/6/2014
	JAPAN	2007-548094	6/26/2007	5055132	8/3/2012
	ISRAEL	183915	6/14/2007	183915	9/1/2011
	E.P.O	05 818 969.7	7/2/2007	1832024	6/6/2018
	U.K.	05 818 969.7	3/22/2018	1832024	6/6/2018
	GERMANY	05 818 969.7	3/22/2018	1832024	6/6/2018
	FRANCE	05 818 969.7	3/22/2018	1832024	6/6/2018
	CHINA	200580044699.0	6/25/2007	ZL200580044699.0	10/9/2012

	AUSTRALIA	2005326877	6/13/2007	2005326877	2/4/2010
	KR	1020040112929	12/27/2004	1079095	10/27/2011
	KR	1020040112926	12/27/2004	1080964	11/1/2011
5	U.S.A.	2016-014792	2/3/2016	9838194	12/5/2017
	U.S.A.	16/394,702	4/25/2019	Pending	
	U.S.A.	2014-513449	10/14/2014	9270365	2/23/2016
	U.S.A.	2012-715278	12/14/2012	8873519	10/28/2014
	JAPAN	2014-547111	6/12/2015	6212048	9/22/2017
	E.P.O	12857526.3	7/15/2014	2792093	7/11/2018
	GERMANY	12857526.3	5/30/2018	2792093	7/11/2018
	FRANCE	12857526.3	5/30/2018	2792093	7/11/2018
	U.K.	12857526.3	5/30/2018	2792093	7/11/2018
	CHINA	2012-80067029	12/14/2012	ZL201280067029.0	9/1/2017
	KR	1020200034567		Pending	
6	U.S.A.	2016-077466	3/22/2016	9713095	7/18/2017
	U.S.A.	15/653,355	7/18/2017	10045304	08/07/2018
	U.S.A.	2014-357557	5/9/2014	9313743	4/12/2016
	U.S.A.	16/293,321	5/5/2019	10609650	3/31/2020
	JAPAN	2014-540937	6/19/2014	5763845	6/19/2015
	E.P.O	12850075	6/4/2014	2782405	8/22/2018
	GERMANY	12850075	6/4/2014	2782405	8/22/2018
	FRANCE	12850075	6/4/2014	2782405	8/22/2018
	U.K.	12850075	6/4/2014	2782405	8/22/2018
	CHINA	201280056210.1	5/15/2014	ZL201280056210.1	5/15/2018
	KR	1020110119154	11/15/2011	10-1867314	6/7/2018
8	U.S.A.	2016-222068	7/28/2016	9680590	6/13/2017
	U.S.A.	2014-147295	1/3/2014	9419739	8/16/2016
	U.S.A.	2011-332089	12/20/2011	8649346	2/11/2014
	JAPAN	2014-134625	6/30/2014	6025783	10/21/2016
	JAPAN	2013-546010	6/14/2013	5575993	7/11/2014
	E.P.O	11850274.9	7/1/2013	Pending	
	CHINA	201180062059	6/21/2013	103270710	3/9/2016
	KR	1020100131864	12/21/2010	10-1867311	6/7/2018
9	U.S.A.	2016-335679	10/27/2016	9860046	1/2/2018
	U.S.A.	16/392,323	4/23/2019	Pending	
	U.S.A.	2016-992186	1/11/2016	9485072	11/1/2016
	U.S.A.	13/877,827	4/4/2013	9237566	1/12/2016
	JAPAN	2013-533775	5/31/2013	5766294	6/26/2015
	E.P.O	11832776.6	4/4/2013	Pending	
	CHINA	201610452850.4	6/21/2016	106059719	6/14/2019

	CHINA	201180049399	4/12/2013	103181109	8/3/2016
	KR	1020100100988	10/15/2010	10-1771550	8/21/2017
10	U.S.A.	14/056,474	10/17/2013	9008046	4/14/2015
	U.S.A.	2011-181456	7/12/2011	8588185	7/19/2013
	E.P.O	11807024.2	12/11/2012	Pending	
	KR	1020100068157	7/14/2010	10-1699023	1/17/2017
11	U.S.A.	2011-098056	4/29/2011	8780840	7/15/2014
12	U.S.A.	2015-733068	6/8/2015	9854545	12/26/2017
	U.S.A.	15/820,980	11/22/2017	Pending	
	U.S.A.	2012-578531	8/10/2012	9054835	6/9/2015
	JAPAN	2015-154385	8/4/2015	6175466	7/14/2017
	E.P.O	11742487.9	9/5/2012	2536227	5/8/2019
	GERMANY	11742487.9	9/5/2012	2536227	5/8/2019
	U.K.	11742487.9	9/5/2012	2536227	5/8/2019
	FRANCE	11742487.9	9/5/2012	2536227	5/8/2019
	SWITZERLAND	11742487.9	9/5/2012	2536227	5/8/2019
	IRELAND	11742487.9	9/5/2012	2536227	5/8/2019
	Luxembourg	11742487.9	9/5/2012	2536227	5/8/2019
	Monaco	11742487.9	9/5/2012	2536227	5/8/2019
	CHINA	201610908740.4	10/18/2016	Pending	
	CHINA	201180014458.7	9/18/2012	ZL201180014458.7	11/16/2016
	KR	10201100086&3	1/28/2011	10-1803015	11/23/2017
14	U.S.A.	15/206,508	7/11/2016	10299251	5/21/2019
	U.S.A.	16/418,708	5/28/2019	Pending	
	U.S.A.	13/875,808	5/2/2013	9392582	7/12/2016
	U.S.A.	13/875,869	5/2/2013	9131482	9/8/2015
	U.S.A.	2013-965837	8/13/2013	9265034	2/16/2016
	U.S.A.	2010-916203	10/29/2010	8538411	9/17/2013
	JAPAN	2014-080506	4/9/2014	5788051	8/7/2015
	JAPAN	2012-536694	4/23/2012	5525055	4/18/2014
	E.P.O	10827139.6	5/23/2012	Pending	
	KR	1020170127789	9/29/2017	10-1828917	2/7/2018
	KR	1020100088151	9/8/2010	10-1785997	10/10/2017
15	U.S.A.	2015-703360	5/4/2015	9787514	10/10/2017
	U.S.A.	16/272,473	2/11/2019	Pending	
	U.S.A.	15/729,604	10/10/2017	10237104	3/19/2019
	U.S.A.	2013-891522	5/10/2013	9025485	5/5/2015
	JAPAN	2015-511380	11/10/2014	6200944	9/1/2017
	E.P.O	13787400.4	12/3/2014	2850757	10/17/2017
	GERMANY	13787400.4	12/3/2014	2850757	10/17/2017

	FRANCE	13787400.4	12/3/2014	2850757	10/17/2017
	U.K.	13787400.4	12/3/2014	2850757	10/17/2017
	CHINA	201380036116.4	1/6/2015	ZL201380036116.4	11/3/2017
	KR	1020120050406	5/11/2012	Pending	
16	U.S.A.	2016-180153	6/13/2016	9742542	8/22/2017
	U.S.A.	2015-801116	7/16/2015	9369251	6/14/2016
	U.S.A.	16/387,174	4/17/2019	Pending	
	U.S.A.	2014-547112	11/18/2014	9088396	7/21/2015
	U.S.A.	2011-816182	2/8/2013	8897182	11/25/2014
	JAPAN	2016-115490	6/9/2016	6185116	8/4/2017
	JAPAN	2015-053011	3/17/2015	5952449	6/17/2016
	JAPAN	2013-524046	2/8/2013	5718464	3/27/2015
	GERMANY	11816634.7	3/11/2013	2605433	2/27/2019
	FRANCE	11816634.7	3/11/2013	2605433	2/27/2019
	SWITZERLAND	11816634.7	3/11/2013	2605433	2/27/2019
	Luxembourg	11816634.7	3/11/2013	2605433	2/27/2019
	MONACO	11816634.7	3/11/2013	2605433	2/27/2019
	IRELAND	11816634.7	3/11/2013	2605433	2/27/2019
	Belgium	11816634.7	3/11/2013	2605433	2/27/2019
	U.K.	11816634.7	3/11/2013	2605433	2/27/2019
	E.P.O	11816634.7	3/11/2013	2605433	2/27/2019
	CHINA	201610412657.8	8/11/2011	ZL201610412657.8	9/24/2019
	CHINA	201180049114.X	4/11/2013	103155456	6/29/2016
	KR	1020100098006	10/7/2010	1719542	3/20/2017
	KR	1020170033713	3/17/2017	1810962	12/24/2017
	KR	1020100098005	10/7/2010	1790502	
17	U.S.A.	2012-807706	12/28/2012	9136924	9/15/2015
	JAPAN	2013-518260	1/4/2013	6293482	2/23/2018
	E.P.O	11803762	2/1/2013	2592763	5/23/2018
	GERMANY	11803762	2/1/2013	2592763	5/23/2018
	FRANCE	11803762	2/1/2013	2592763	5/23/2018
	U.K.	11803762	2/1/2013	2592763	5/23/2018
	CHINA	201180037814.7	1/31/2013	ZL201180037814.7	11/17/2017
	KR	1020160171540	12/15/2016	10-1771549	8/21/2017
18	U.S.A.	2016-151296	5/10/2016	9948440	4/17/2018
	U.S.A.	2014-299679	6/9/2014	9344245	5/17/2016
	U.S.A.	15/911,518	3/5/2018	Pending	
	U.S.A.	2011-149225	5/31/2011	8787216	7/22/2014
	JAPAN	2013-513109	11/27/2012	5931056	5/13/2016
	E.P.O	11790009	12/5/2012	Pending	

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	CHINA	201180037855.6	1/31/2013	ZL201180037855.6	11/30/2016
	KR	1020100055073	6/10/2010	10-1790505	10/20/2017
19	U.S.A.	2016-192233	6/24/2016	9893866	2/13/2018
	U.S.A.	2014-464041	8/20/2014	9380581	6/28/2016
	U.S.A.	2013-043005	10/1/2013	8837452	9/16/2014
	U.S.A.	2011-008685	1/18/2011	8576822	11/5/2013
	JAPAN	2012-548900	7/11/2012	5855016	12/18/2015
	E.P.O	11733132	8/17/2012	Pending	
	U.S.A.	16/285,957	2/26/2019	10567140	2/18/2020
	U.S.A.	15/858,921	12/29/2017	10218485	2/26/2019
	CHINA	201180014290.X	9/17/2012	102804625	11/13/2018
	KR	1020100004219	1/18/2010	1740221	
20	U.S.A.	2009-505707	5/2/2012	8811518	8/19/2014
	KR	1020127011219	4/30/2012	1627393	5/30/2016
21	U.S.A.	2016-131725	4/18/2016	9825686	11/21/2017
	U.S.A.	2009-500288	4/4/2012	9319252	4/19/2016
	U.S.A.	16/203,319	11/28/2018	Pending	
	U.S.A.	15/814,605	11/16/2017	10153821	12/11/2018
	KR	1020127008173	3/29/2012	1621376	5/10/2016
22	U.S.A.	2015-279139	9/28/2016	10057940	8/21/2018
	U.S.A.	2015-801280	7/16/2015	9474025	10/18/2016
	U.S.A.	2013-847319	3/19/2013	9088992	7/21/2015
	KR	1020120027938	3/19/2012	10-1868865	6/12/2018
23	U.S.A.	2016-183158	6/15/2016	9730265	8/8/2017
	U.S.A.	16/275,039	2/13/2019	Pending	
	U.S.A.	2014-560838	12/4/2014	9374213	6/21/2016
	U.S.A.	2012-651034	10/12/2012	8917619	12/23/2014
	KR	1020110110798	10/27/2011	10-1841693	3/19/2018
24	U.S.A.	2016-341296	11/2/2016	9955376	4/24/2018
	U.S.A.	16/288,278	2/28/2019	Pending	
	U.S.A.	2015-937348	11/10/2015	9516538	12/6/2016
	U.S.A.	2013-984476	8/8/2013	9191833	11/17/2015
	E.P.O	12744488.3	8/9/2013	Notice of Allowance at 1/7/2020 (Issue fee due 5/7/2020)	
	CHINA	201610397886.7	6/7/2016	106060866B	1/7/2020
	CHINA	201280014327	9/22/2013	103444100	6/29/2016
	KR	1020170130604	10/11/2017	1860863	5/17/2018
27	U.S.A.	2014-191178	2/26/2014	9124688	9/1/2015
	U.S.A.	2009-553328	9/3/2009	8675844	3/18/2014

	U.S.A.	2003-730853	12/8/2003	7660404	2/9/2010
	HONG KONG	5101471	2/22/2005	1069062	2/12/2010
	E.P.O	06019434.7	12/5/2003	1727386	3/4/2009
	U.K.	06019434.7	9/18/2006	1727386	3/4/2009
	U.K.	03257661.3	12/5/2003	1427242	11/15/2006
	FRANCE	06019434.7	9/18/2006	1727386	3/4/2009
	E.P.O	03257661.3	12/5/2003	1427242	11/15/2006
	FRANCE	03257661.3	12/5/2003	1427242	11/15/2006
	GERMANY	06019434.7	9/18/2006	1727386	3/4/2009
	GERMANY	03257661.3	12/5/2003	1427242	11/15/2006
	CHINA	200310124920.6	12/7/2003	100558200	11/4/2009
	KR	1020020077576	12/7/2002	500670	7/1/2005
28	U.S.A.	2002-194038	7/11/2002	6809641	10/26/2004
	JAPAN	2002-196495	7/4/2002	3684373	6/10/2005
	CHINA	02140676.6	7/12/2002	101271871	8/23/2006
	KR	1020010041909	7/12/2001	420395	2/16/2004
29	U.S.A.	14/225,729	3/26/2014	8933955	12/23/2014
	U.S.A.	2013-035625	9/24/2013	8706168	4/22/2014
	U.S.A.	2012-654043	10/17/2012	8554185	10/8/2013
	U.S.A.	2009-412079	3/26/2009	8311519	11/13/2012
	JAPAN	2009-133842	6/4/2009	4764496	6/17/2011
	KR	1020080052642	6/4/2008	1481408	1/6/2015
30	U.S.A.	2004-007603	12/7/2004	7260419	8/21/2007
	KR	1020030088563	12/8/2003	603437	7/13/2006
31	U.S.A.	14/061316	10/23/2013	Pending	
	U.S.A.	2012-649539	10/11/2012	RE44620	7/9/2013
	U.S.A.	2011-300799	11/21/2011	RE43789	11/6/2012
	U.S.A.	2009-612327	11/4/2009	RE42996	12/6/2011
	U.S.A.	2004-882604	6/30/2004	7292561	11/6/2007
	KR	1020030087886	12/5/2003	633741	10/4/2006
32	U.S.A.	2013-861177	4/11/2013	9661113	5/23/2017
	U.S.A.	2010-716600	3/3/2010	8433379	4/30/2013
	U.S.A.	2005-106118	4/13/2005	7693558	4/6/2010
	KR	1020040025922	4/14/2004	598062	6/30/2006
33	U.S.A.	2011-171344	6/28/2011	8200899	6/12/2012
	U.S.A.	2009-362760	1/30/2009	7991958	8/2/2011
	KR	1020080046505	5/20/2008	985617	9/29/2010
34	U.S.A.	2005-295202	12/6/2005	7567530	7/28/2009
37	U.S.A.	2002-253256	9/24/2002	7136671	11/14/2006
38	U.S.A.	2015-929965	11/2/2015	9729699	8/8/2017

	U.S.A.	2014-196273	3/4/2014	9178982	11/3/2015
	U.S.A.	2013-746125	1/21/2013	8699987	4/15/2014
	U.S.A.	2009-625191	11/24/2009	8374572	2/12/2013
	U.S.A.	15/672,018	8/8/2017	10158752	12/18/2018
	U.S.A.	2003-749788	12/30/2003	7643815	1/5/2010
40	U.S.A.	2010-944436	11/11/2010	8060114	11/15/2011
	U.S.A.	2010-693142	1/25/2010	7912482	3/22/2011
	KR	1020040088333	11/2/2004	0632667	9/28/2006
	U.S.A.	2004-021778	12/23/2004	7668553	2/23/2010
41	U.S.A.	2004-899638	7/26/2004	7151487	12/19/2006
	U.S.A.	2003-749598	12/30/2003	6784829	8/31/2004
	CHINA	200410064136.5	8/19/2004	ZL200410064136.5	4/20/2011
	KR	1020030057848	8/21/2003	540248	12/23/2005
42	U.S.A.	2003-750000	12/30/2003	7006037	2/28/2006
	KR	1020030033022	5/23/2003	543308	1/6/2006
43	U.S.A.	16/287,787	2/27/2019	Pending	
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44	U.S.A.	2011-275103	10/17/2011	8446915	5/21/2013
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	U.S.A.	2006-441981	5/26/2006	7693163	4/6/2010
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45	U.S.A.	2004-933670	9/3/2004	7102196	9/5/2006
	KR	1020030062570	9/8/2003	539960	12/22/2005
46	U.S.A.	2002-214430	8/8/2002	6801271	10/5/2004
	JAPAN	2002-214711	7/24/2002	3773472	2/24/2006
	E.P.O	02014550	7/1/2002	1 316 841	1/1/2014
	U.K.	02014550	7/1/2002	1 316 841	1/1/2014
	FRANCE	02014550	7/1/2002	1 316 841	1/1/2014
	GERMANY	02014550	7/1/2002	02 014 550.4	1/1/2014
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47	U.S.A.	2002-071750	2/6/2002	6925313	8/2/2005
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	FRANCE	02250854	2/7/2002	1231757	11/15/2006
	GERMANY	02250854	2/7/2002	1231757	11/15/2006
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48	U.S.A.	2009-645912	12/23/2009	8270999	9/18/2012
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49	U.S.A.	2013-860672	4/11/2013	9204118	8/14/2015
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	KR	1020040101848	12/6/2004	620741	8/29/2006
50	U.S.A.	2005-106160	4/13/2005	7283839	10/16/2007
	HONG KONG	06103630.4	3/22/2006	1083574	10/15/2010
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	FRANCE	05252337	4/14/2005	1587288	11/3/2010
	GERMANY	05252337	4/14/2005	1587288	11/3/2010
	KR	1020040083073	10/18/2004	572464	4/18/2006
	CHINA	200510079253.3	4/14/2005	101694372	5/26/2010
51	U.S.A.	2000-655036	9/5/2000	6557010	4/29/2003
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52	U.S.A.	2002-185141	6/27/2002	7103387	9/5/2006
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	E.P.O	02254584	6/28/2002	1309157	8/17/2011
	U.K.	02254584	6/28/2002	1309157	8/17/2011
	FRANCE	02254584	6/28/2002	1309157	8/17/2011
	GERMANY	02254584	6/28/2002	1309157	8/17/2011
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54	KR	1020050009451	2/2/2005	656670	12/5/2006
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55	U.S.A.	2012-676214	11/14/2012	8588755	6/17/2013
	U.S.A.	12/816,688	6/16/2010	8331920	12/11/2012
	KR	1020090065796	7/20/2009	1026905	3/28/2011
56	U.S.A.	2006-580741	10/12/2006	7636845	12/22/2009
	KR	1020050123711	12/15/2005	755536	8/29/2007
57	U.S.A.	2011-311458	12/5/2011	8565724	10/22/2013
	U.S.A.	2008-150905	5/1/2008	8078145	12/13/2011
	U.S.A.	2003-602810	6/24/2003	7386297	6/10/2008
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	KR	1020020085938	12/28/2002	551421	2/3/2006
62	U.S.A.	2016-082832	3/28/2016	9596352	3/14/2017
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	U.S.A.	2013-058968	10/21/2013	9008637	4/14/2015
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	U.S.A.	15/457,560	3/13/2017	10009471	06/26/2018
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63	U.S.A.	15/338,993	10/31/2016	9769776	9/19/2017
	U.S.A.	15/709,185	9/20/2017	10015759	7/3/2018
	U.S.A.	16/424,258	5/28/2019	10582460	3/3/2020
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	U.S.A.	13/849,296	3/22/2013	8964645	2/24/2015
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	U.S.A.	2015-707736	5/8/2015	9191932	11/17/2015
	U.S.A.	2013-888891	5/7/2013	9030973	5/12/2015
	JAPAN	2015-511358	11/7/2014	6132370	4/28/2017
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	GERMANY	13788210.6	5/7/2013	2850758	9/5/2018
	FRANCE	13788210.6	5/7/2013	2850758	9/5/2018
	U.K.	13788210.6	5/7/2013	2850758	9/5/2018

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65	U.S.A.	14/589971	1/5/2015	10004062	6/19/2018
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66	U.S.A.	2014-754045	6/29/2015	10103916	10/16/2018
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67	U.S.A.	15/167,518	5/27/2016	10162490	12/25/2018
	U.S.A.	14/816,736	8/3/2015	9357363	5/31/2016
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	FRANCE	09156335.3	3/26/2009	2117208	1/26/2011
	U.K.	09156335.3	3/26/2009	2117208	1/26/2011
	NETHERLAND	09156335.3	3/26/2009	2117208	1/26/2011
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68	U.S.A.	15/017,133	2/5/2016	Pending	
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69	U.S.A.	2016-010629	1/29/2016	9575631	2/21/2017
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71	U.S.A.	2016-354691	11/17/2016	9930499	3/27/2018
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	FRANCE	11176526.9	11/29/2018	2424170	12/19/2018
	U.K.	11176526.9	11/29/2018	2424170	12/19/2018
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75	U.S.A	2005-285960	11/23/2005	7881723	2/1/2011
	CHINA	200510137366.4	11/23/2005	ZL200510137366.4	6/16/2010
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76	JAPAN	2013-021345	2/6/2013	5411369	11/15/2013
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77	U.S.A.	2011-195563	8/1/2011	8606284	12/10/2013
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	FRANCE	11177039.2	8/10/2011	2424309	12/4/2013
	GERMANY	11177039.2	8/10/2011	2424309	12/4/2013
	CHINA	201110253571.2	8/30/2011	102387527	12/3/2014
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78	U.S.A.	2013-857294	4/5/2013	9072108	2/18/2015
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	JAPAN	2007-223594	8/30/2007	4685842	1/13/2011
	U.K.	07253398	8/29/2007	1895795	3/9/2016
	FRANCE	07253398	8/29/2007	1895795	3/9/2016
	E.P.O	07253398	8/29/2007	1895795	3/9/2016
	GERMANY	07253398	8/29/2007	1895795	3/9/2016
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	E.P.O	07253403	8/29/2007	1895678	7/11/2018
	GERMANY	07253403	5/29/2018	1895678	7/11/2018
	FRANCE	07253403	5/29/2018	1895678	7/11/2018
	U.K.	07253403	5/29/2018	1895678	7/11/2018
	IRELAND	07253403.5	5/29/2018	1895678	7/11/2018

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	KR	1020060082991	8/30/2006	753369	8/23/2007
81	U.S.A.	2005-285943	11/23/2005	7577115	8/18/2009
	E.P.O	05257261.7	11/25/2005	1662671	11/3/2010
	NETHERLAND	05257261.7	11/25/2005	1662671	11/3/2010
	U.K.	05257261.7	11/25/2005	1662671	11/3/2010
	FRANCE	05257261.7	11/25/2005	1662671	11/3/2010
	FINLAND	05257261.7	11/25/2005	1662671	11/3/2010
	GERMANY	05257261.7	11/25/2005	1662671	11/3/2010
	CHINA	200510121565.6	11/25/2005	ZL200510121565.6	4/30/2008
	KR	1020040097330	11/25/2004	622149	9/1/2006
83	U.S.A.	2002-330737	12/27/2002	7167716	1/23/2007
	HONG KONG	03108579.9	11/25/2003	1056450	8/18/2006
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84	U.S.A.	2011-143688	7/7/2011	8559480	10/15/2013
	JAPAN	2011-546214	7/19/2011	5228113	3/22/2013
	E.P.O	10733619.0	6/29/2011	2381584	8/8/2018
	FRANCE	10733619.0	1/15/2010	2381584	8/8/2018
	GERMANY	10733619.0	1/15/2010	2381584	8/8/2018
	U.K.	10733619.0	1/15/2010	2381584	8/8/2018
	CHINA	201080004784.5	7/18/2011	ZL 201080004784.5	11/26/2014
	KR	1020090004682	1/20/2009	991957	10/28/2010
85	U.S.A.	2009-629570	12/2/2009	8345867	1/1/2013
	JAPAN	2011-538568	5/27/2011	5230820	3/29/2013
	E.P.O	9830590.7	12/2/2009	2359512	8/24/2016
	GERMANY	9830590.7	12/2/2009	2359512	8/24/2016
	FRANCE	09830590.7	12/2/2009	2359512	8/24/2016
	U.K.	09830590.7	12/2/2009	2359512	8/24/2016
	CHINA	200980148059.5	5/31/2011	ZL200980148059.2	7/28/2014
	KR	1020080121495	12/2/2008	1037520	5/20/2011
86	U.S.A.	2010-383821	1/12/2012	9009207	4/14/2015
	E.P.O	10800014.2	2/10/2012	2456117	9/9/2015
	U.K.	10800014.2	2/10/2012	2456117	9/9/2015
	FRANCE	10800014.2	2/10/2012	2456117	9/9/2015
	GERMANY	10800014.2	2/10/2012	2456117	9/9/2015
	CHINA	201080037807.2	2/24/2012	ZL201080037807.2	4/15/2016
	KR	1020090063719	7/13/2009	1685173	12/5/2016
88	U.S.A.	12/582,164	10/20/2009	8675510	10/31/2013
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89	U.S.A.	12/958,749	12/2/2010	Pending	

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	KR	1020050088083	9/22/2005	694378	3/6/2007
90	U.S.A.	16/452,244	6/25/2019	Pending	
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91	U.S.A.	2011-177761	7/7/2011	8929223	12/17/2014
	KR	1020100136900	12/28/2010	1266692	5/14/2013
92	U.S.A.	12/832,665	7/8/2010	8301151	6/29/2012
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93	U.S.A.	2009-539364	10/12/2009	RE43930	8/30/2012
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94	U.S.A.	12/759,974	4/14/2010	RE43059	1/3/2012
	U.S.A.	2003-729755	12/4/2003	7366222	4/29/2008
	KR	1020020083746	12/24/2002	470401	1/27/2005
95	U.S.A.	2005-263858	11/2/2005	7904025	3/8/2011
	KR	1020040103715	12/9/2004	698665	3/15/2007
96	U.S.A.	12/861,637	8/23/2010	8098624	1/17/2012
	U.S.A.	2005-132400	5/19/2005	7801074	9/21/2010
	KR	1020040059401	7/28/2004	620713	8/29/2006
97	U.S.A.	2003-744321	12/22/2003	7333828	2/19/2008
	KR	2003-0098663	12/31/2002	598055	7/10/2006
98	U.S.A.	2003-749456	12/31/2003	7123912	10/17/2006
	KR	1020030026991	4/29/2003	0592885	6/16/2006

AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court for the Eastern District of Texas, Texarkana Division on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
5:22-CV-00113	9/2/2022	for the Eastern District of Texas, Texarkana Division

PLAINTIFF	DEFENDANT
PANTECH CORPORATION and PANTECH WIRELESS, LLC	LG ELECTRONICS INC., and LG ELECTRONICS U.S.A., INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	9,136,924	9/15/2015	Pantech Corporation
2	9,854,545	12/26/2017	Pantech Corporation
3	10,869,247	12/15/2020	Pantech Wireless
4	9,313,809	4/12/2016	Pantech Wireless
5	9,065,486	6/23/2015	Pantech Wireless

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**

AO 120 (Rev. 08/10)

TO:	**Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court for the Eastern District of Texas, Texarkana Division on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
5:22-CV-00113	9/2/2022	for the Eastern District of Texas, Texarkana Division

PLAINTIFF	DEFENDANT
PANTECH CORPORATION and PANTECH WIRELESS, LLC	LG ELECTRONICS INC., and LG ELECTRONICS U.S.A., INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	7,283,839	10/16/2007	Pantech Corporation
2	9,575,631	2/21/2017	Pantech Corporation
3			
4			
5			

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**