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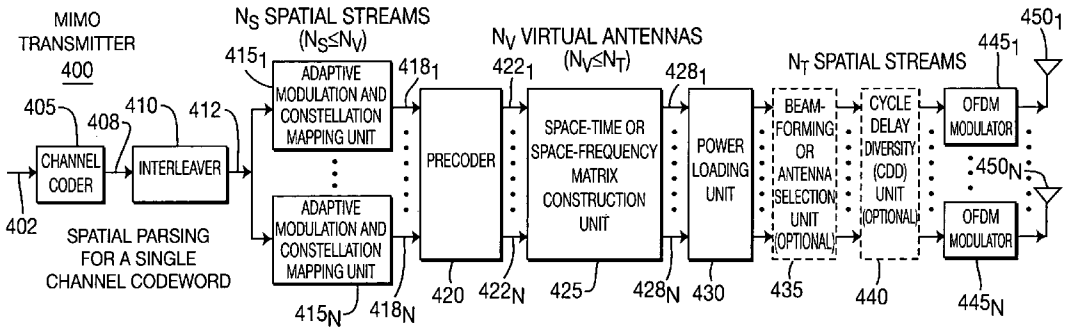
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30 October 2008

(54) Title: MIMO TRANSMITTER AND RECEIVER FOR SUPPORTING DOWNLINK COMMUNICATION OF SINGLE CHANNEL CODEWORDS



(57) Abstract: The downlink (DL) communication of single channel codewords is supported by providing a multiple-input multiple-output (MIMO) transmitter and receiver. The transmitter includes N_T transmit antennas for transmitting spatial streams to a receiver having N_R receive antennas, a precoder and a space- time or space-frequency matrix construction unit in communication with the precoder and the transmit antennas. The space-time or space-frequency matrix construction unit constructs a matrix that defines a threaded algebraic space- time (TAST) codeword based on a number of virtual antennas, N_V, and the number of transmit antennas, N_T. The transmitter operates in an open loop mode when no feedback information from the receiver is available, a semi-open loop mode when channel rank information is available, and a closed loop mode when channel state information (CSI) is available. The receiver is configured to provide feedback to the transmitter on a per received spatial stream basis.

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INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L1/06 H04L1/00

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, INSPEC, PAJ, IBM-TDB, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	HESHAM EL GAMAL ET AL: "Universal Space-Time Coding" IEEE TRANSACTIONS ON INFORMATION THEORY, IEEE SERVICE CENTER, PISCATAWAY, NJ, US, vol. 49, no. 5, 1 May 2003 (2003-05-01), pages 1097-1119, XP011074756 ISSN: 0018-9448 page 1098 - page 1099, Section III. A. page 1101, left-hand column, 2nd paragraph page 1102 - 1103, Section III. D. page 1102, left-hand column, 2nd paragraph figure 1 -----	1-5, 10-14, 19-24
Y	US 2006/018397 A1 (SAMPATH HEMANTH [US] ET AL) 26 January 2006 (2006-01-26) paragraph [0029] - paragraph [0030] ----- -/--	1-5, 10-14, 22-24

[X] Further documents are listed in the continuation of Box C. [X] 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 document 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 August 2008	10/09/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Baltersee, Jens

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1 255 369 A (ERICSSON TELEFON AB L M [SE]) 6 November 2002 (2002-11-06) paragraph [0027] -----	1-5, 10-14, 22-24
Y	BOSISIO R ET AL: "Fair scheduling and orthogonal linear precoding/decoding in broadcast MIMO systems" PERSONAL, INDOOR AND MOBILE RADIO COMMUNICATIONS, 2005. PIMRC 2005. IE EE 16TH INTERNATIONAL SYMPOSIUM ON BERLIN, GERMANY 11-14 SEPT. 2005, PISCATAWAY, NJ, USA,IEEE, vol. 2, 11 September 2005 (2005-09-11), pages 832-836, XP010926421 ISBN: 978-978-38007-2-4 page 832, left-hand column, first paragraph of the Introduction page 833, left-hand column, first two paragraphs of Section II. page 834, right-hand column, Section IV.A. -----	19,20
Y	EP 1 594 245 A (SAMSUNG ELECTRONICS CO LTD [KR]) 9 November 2005 (2005-11-09) paragraph [0071] - paragraph [0073] figures 5,6 -----	21

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2007/018727

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2006018397 A1	26-01-2006	NONE	
EP 1255369 A	06-11-2002	WO 02091657 A1	14-11-2002
		TW 571525 B	11-01-2004
		US 2003003863 A1	02-01-2003
EP 1594245 A	09-11-2005	AU 2005241837 A1	17-11-2005
		CA 2557736 A1	17-11-2005
		CN 1943133 A	04-04-2007
		JP 2007527680 T	27-09-2007
		WO 2005109679 A1	17-11-2005
		KR 20060047746 A	18-05-2006
		US 2005249306 A1	10-11-2005

INTERNATIONAL SEARCH REPORT

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Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers allsearchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search reportcovers only those claims for which fees were paid, specifically claims Nos.:

1-5, 10-14, 19-24

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-5, 10-14, 22-24

   Enabling adaptive modulation
   ---

2. claims: 6, 8, 9, 15, 17, 18

   Further increasing spatial diversity
   ---

3. claims: 7, 16

   Further increasing frequency diversity
   ---

4. claims: 19, 20

   Exploiting the broadcasting gain of the MIMO downlink
   ---

5. claim: 21

   Increasing the reliability of the TAST transmitter