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APPLICATION NUMBER	PATENT NUMBER	GROUP ART UNIT	FILE WRAPPER LOCATION
60/462,286			9200Q 0021 068 04



Correspondence Address/Fee Address Change

The following fields have been set to Customer Number 23696 on 01/19/2012

- Correspondence Address
- Maintenance Fee Address

The address of record for Customer Number 23696 is:

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
60/462,286	04/10/2003	Vincent K. Jones IV	070903PI/QUALP700US

CONFIRMATION NO. 8359

POA ACCEPTANCE LETTER



70797
Amin, Turocy & Calvin LLP
1900 E. 9th Street
24th Floor, National City Center
Cleveland, OH 44114

Date Mailed: 02/28/2008

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 02/15/2008.

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.

/deelliott/

Office of Initial Patent Examination (571) 272-4000 or 1-800-PTO-9199



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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
60/462,286	04/10/2003	Vincent K. Jones IV	070903PI/QUALP700US

CONFIRMATION NO. 8359

POWER OF ATTORNEY NOTICE



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Date Mailed: 02/28/2008

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 02/15/2008.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71.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).

/deelliott/

Office of Initial Patent Examination (571) 272-4000 or 1-800-PTO-9199

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REVOCATION OF POWER OF ATTORNEY WITH NEW POWER OF ATTORNEY AND CHANGE OF CORRESPONDENCE ADDRESS	Application Number	60/462,286
	Filing Date	4/10/03
	First Named Inventor	Vincent K. Jones IV
	Art Unit	
	Examiner Name	
	Attorney Docket Number	070903P1/QUALP700US

I hereby revoke all previous powers of attorney given in the above-identified application.

☐ A Power of Attorney is submitted herewith.

OR

☒ I hereby appoint the practitioners associated with the Customer Number:

70797

☒ Please change the correspondence address for the above-identified application to:

☒ The address associated with
Customer Number:

70797

OR

☐ Firm or
Individual Name

Address

City

State

Zip

Country

Telephone

Email

I am the:

☐ Applicant/Inventor.

☒ Assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96)
SIGNATURE of Applicant or Assignee of Record

Signature

Name

Thomas Rouse, Vice President, Chief Patent Counsel

Date

July 31, 2007

Telephone

(858) 651-6732

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below.

☒ *Total of 2 forms are submitted.

This collection of information is required by 37 CFR 1.36. 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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STATEMENT UNDER 37 CFR 3.73(b)Applicant/Patent Owner: QUALCOMM IncorporatedApplication No./Patent No.: 60/462,286 Filed/Issue Date: 4/10/03Entitled: CHANNEL ESTIMATION FOR IEEE 802.11A AND EXTENDED RATESQUALCOMM Incorporated, 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; or
2. ☐ an assignee of less than the entire right, title and interest
(The extent (by percentage) of its ownership interest is _____ %)

in 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 018932, Frame 0566, or for which a copy thereof 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:

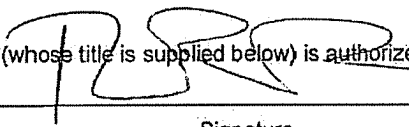
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☐ Additional documents in the chain of title are listed on a supplemental sheet.

☒ 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.



Signature

Date_____
Thomas Rouse_____
(858) 651-6732_____
Printed or Typed Name_____
Telephone Number_____
Vice President, Chief Patent Counsel
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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Electronic Acknowledgement Receipt

EFS ID:	2869790
Application Number:	60462286
International Application Number:	
Confirmation Number:	8359
Title of Invention:	Channel estimation for IEEE 802.11a and extended rates
First Named Inventor/Applicant Name:	Vincent K. Jones
Customer Number:	20350
Filer:	Himanshu Amin/Casey Martin
Filer Authorized By:	Himanshu Amin
Attorney Docket Number:	021245-000300US
Receipt Date:	15-FEB-2008
Filing Date:	10-APR-2003
Time Stamp:	17:12:34
Application Type:	Provisional

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	POA.pdf	473589 cb53e9615f66bae13c719b5c0f8cbd119a207e4f	no	1

Warnings:

Information:

2	Assignee showing of ownership per 37 CFR 3.73(b).	Statementunder373b.pdf	486400 f11ea79951a5e29230863cf6a8afd3c75732a328	no	1
Warnings:					
Information:					
Total Files Size (in bytes):			959989		
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. <u>New Applications Under 35 U.S.C. 111</u> 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. <u>National Stage of an International Application under 35 U.S.C. 371</u> 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. <u>New International Application Filed with the USPTO as a Receiving Office</u> 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.					

04-14-03

60462286

PTO/SB/16 (10-01)

Approved for use through 10/31/2002. OMB 0651-0032

Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

Express Mail Label No. EL 951 986 984 US

INVENTOR(S)					
Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)			
Vincent K.	Jones, IV	Redwood City, CA			
James	Gardner	San Ramon, CA			
☒ Additional inventors are being named on the 1 separately numbered sheets attached hereto					
TITLE OF THE INVENTION (500 characters max)					
CHANNEL ESTIMATION FOR IEEE 802.11A AND EXTENDED RATES					
CORRESPONDENCE ADDRESS					
Direct all correspondence to:					
☒ Customer Number		20350		Place Customer Number Bar Code Label here	
OR		Type Customer Number here			
☐ Firm or Individual Name					
Address					
Address					
City		State	ZIP		
Country		Telephone	Fax		
ENCLOSED APPLICATION PARTS (check all that apply)					
☒ Specification Number of Pages		7		☐ CD(s), Number	
☒ Drawing(s) Number of Sheets		2		☐ Other (specify)	
☒ Application Data Sheet. See 37 CFR 1.76					
METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT					
☒ Applicant claims small entity status. See 37 CFR 1.27.					
☐ A check or money order is enclosed to cover the filing fees					
☒ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number:				FILING FEE AMOUNT (\$)	
☐ Payment by credit card. Form PTO-2038 is attached.				20-1430 80	
The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.					
☒ No.					
☐ Yes, the name of the U.S. Government agency and the Government contract number are:					

Respectfully submitted,

SIGNATURE

Date

9/9/03

TYPED or PRINTED NAME Philip H. Albert

REGISTRATION NO. 35,819

(if appropriate)

Docket Number: 021245-000300US

TELEPHONE 415-576-0200

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

This collection of information is required by 37 CFR 1.51. The information is used by the public to file (and by the PTO to process) a provisional application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 8 hours to complete, including gathering, preparing, and submitting the complete provisional application to the PTO. 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, Washington, D.C., 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Box Provisional Application, Assistant Commissioner for Patents, Washington, D.C. 20231.

SF 1445429 v1

04/10/03



JC678 U.S. PTO

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60/462286



04/10/03

PROVISIONAL APPLICATION COVER SHEET
Additional Page

PTO/SB/16 (10-01)

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Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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Docket Number 021245-000300US

INVENTOR(S)/APPLICANT(S)		
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D.J. Richard	van Nee	De Meern, Netherlands

Number 2 of 2

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.

SF 1445429 v1

Application Data Sheet**Application Information**

Application number::

Filing Date::

Application Type::

Provisional

Subject Matter::

Utility

Suggested classification::

Suggested Group Art Unit::

CD-ROM or CD-R??::

Number of CD disks::

Number of copies of CDs::

Sequence Submission::

Computer Readable Form (CRF)?::

Number of copies of CRF::

Title::

CHANNEL ESTIMATION FOR IEEE 802.11A
AND EXTENDED RATES

Attorney Docket Number::

021245-000300US

Request for Early Publication::

No

Request for Non-Publication::

No

Suggested Drawing Figure::

Total Drawing Sheets::

2

Small Entity?::

Yes

Latin name::

Variety denomination name::

Petition included?::

No

Petition Type::

Licensed US Govt. Agency::

Contract or Grant Numbers One::

Secrecy Order in Parent Appl.::

No

Applicant Information

Applicant Authority Type:: Inventor
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Status:: Full Capacity
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Middle Name::
Family Name:: van Nee
Name Suffix::

City of Residence:: De Meern
State or Province of Residence::
Country of Residence:: Netherlands
Street of Mailing Address:: Mauritslaan 57
City of Mailing Address:: De Meern
State or Province of mailing address::
Country of mailing address:: Netherlands
Postal or Zip Code of mailing address:: 3454 XR

Correspondence Information

Correspondence Customer Number:: 20350

Representative Information

Representative Customer Number:: 20350

Domestic Priority Information

Application:: Continuity Type:: Parent Application:: Parent Filing Date::

Foreign Priority Information

Country::

Application number::

Filing Date::

Assignee Information

Assignee Name::

Street of mailing address::

City of mailing address::

State or Province of mailing address::

Country of mailing address::

Postal or Zip Code of mailing address::

Attorney Docket No.: 021245-000300US

PROVISIONAL

PATENT APPLICATION

CHANNEL ESTIMATION FOR IEEE 802.11A AND EXTENDED RATES

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Assignee: Airgo Networks, Inc.
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Palo Alto, CA, 94304

Entity: Small business concern

CHANNEL ESTIMATION FOR IEEE 802.11A AND EXTENDED RATES**BACKGROUND OF THE INVENTION**

[0001] The IEEE 802.11a standard defines data rates of 6 Mbps (mega-bits per second) up to 54 Mbps. It is possible to extend those rates using multiple antenna techniques (MIMO), wherein multiple data streams are multiplexed spatially. Such an extension to IEEE 802.11a can be expected to involve changes in the preamble, as there is a need to get channel estimates from different transmitters, whereas the 802.11a preamble only deals with one transmitted signal.

BRIEF SUMMARY OF THE INVENTION

10 [0002] Channel estimates can be obtained for extended 802.11a rates, based on a modified preamble. An improved channel estimation technique for legacy 802.11a rates is described, as well as a way to track channel variations throughout a packet.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Fig. 1 illustrates the structure of an 802.11a preamble.

15 [0004] Fig. 2 illustrates training value sequences.

DETAILED DESCRIPTION OF THE INVENTION

[0005] Fig. 1 shows the structure of an IEEE 802.11a preamble. The training symbol, L , comprises 52 subcarriers with known training values that can be used for estimating the channel in a receiver. The known training values are given by the sequence L_1 in Fig. 2, but they can also be as given by L_2 or L_3 for improved channel estimation or for channel estimation of extended rate packets.

[0006] Applying a conventional channel estimation process for an 802.11a packet modified for multiple receive antennas is as follows.

1) Take the FFT of the average of the first and second half of the long training symbol (both halves are 64 samples at a 20 MHz sampling rate) for each receive antenna. The output $s_i(k)$ comprises 64 complex values per receive antenna containing channel

amplitudes and phases, as well as phase shifts caused by one of the training sequences L_1 , L_2 , or L_3 .

2) Multiply all subcarrier values $s_i(k)$ by the sequence L_1 for each receive antenna i . The result is 52 complex reference channel values per receive antenna.

5 Improved Channel Estimation

[0007] It is possible to improve the signal-to-noise ratio of the channel estimates by making use of the fact that the channel impulse response is generally limited to a value that is significantly smaller than the symbol period of 4 μ s. For the IEEE 802.11a rates, an improved channel estimation method is described below where the impulse response is adaptively truncated.

1) For each receive antenna n , average first and second half of the long training symbol: $s_n[i] = \frac{r_n[i + \tau] + r_n[i + \tau + 64]}{2}$, $i=0, \dots, 63$, where $r_n[i]$ are the received complex input samples at a sampling rate of 20 MHz for receiver n , and τ is the estimated starting sample for the channel estimation, which should be about 16 to 32 samples after the start of the long training symbol.

2) Take a 64-point FFT of s_n : $S_n[k] = \sum_{i=0}^{63} s_n[i] \exp(-j \frac{2\pi i k}{64})$

3) Multiply the FFT outputs $S_n[k]$ by the known long training symbol values $L_2[k]$.

$$S_{n0}[k] = L[k] S_n[k] \quad k = 0, \dots, 63$$

4) Interpolate the 'missing subcarrier' at DC.

$$S_{n0}[0] = \sum_{i=1}^{63} S_{n0}[i] \exp(-j \frac{(i-32)\pi}{32})$$

5) Take a 64-point IFFT of all interpolated spectra $S_{n0}[k]$, resulting in channel impulse response estimates for each receiver:

$$\hat{h}_{n0}[i] = \sum_{k=0}^{63} S_{n0}[k] \exp(j \frac{2\pi i k}{64})$$

6) To increase the SNR of the channel estimates, the impulse responses are cut off at the point where the signal-to-noise+truncation power is maximized. This cutoff length k_c is:

$$k_c = \min_k (P_h[k] + k\sigma_n^2), \quad k = k_o, \dots, 63$$

5 7) Calculate the 64-point FFT of the truncated impulse responses. The FFT outputs are the desired channel estimates $\hat{H}_{n0}[k]$.

$$\hat{H}_{n0}[k] = \sum_{i=0}^{63} \hat{h}_{n0}[i] \exp(-j \frac{2\pi i k}{64})$$

Channel Estimates for Extended Rates

10 [0008] For MIMO-OFDM with two independent transmitters, one process for obtaining the channel estimates is as follows:

1) For each receive antenna n , average first and second half of the long training symbol: $s_n[i] = \frac{r_n[i + \tau] + r_n[i + \tau + 64]}{2}$, $i=0, \dots, 63$, where $r_n[i]$ are the received complex input

15 samples at a sampling rate of 20 MHz for receiver n , and τ is the estimated starting sample for the channel estimation, which should be about 16 to 32 samples after the start of the long training symbol.

2) Take a 64-point FFT of s_n : $S_n[k] = \sum_{i=0}^{63} s_n[i] \exp(-j \frac{2\pi i k}{64})$

3) Split the FFT outputs $S_n[k]$ into two sets with even and odd subcarriers for transmitter 0 and 1, respectively, and multiply the samples with the known long training
20 symbol values $L_3[k]$.

$$\begin{aligned} S_{n0}[k] &= L_0[2k] S_n[2k] & k &= 0, \dots, 31 \\ S_{n1}[k] &= L_1[2k + 1] S_n[2k + 1] \end{aligned}$$

4) Interpolate the 'missing subcarrier' at DC ($k=0$), so that 32 points are available for a 32 point FFT to obtain channel impulse response estimates, from only 31 valid samples. ✓
The DC subcarrier is interpolated as:

$$S_{n0}[0] = \sum_{i=1}^{31} S_{n0}[i] \exp(-j \frac{(i-16)\pi}{16})$$

5) Take a 32-point IFFT of all interpolated spectra $S_{nm}[k]$, resulting in channel impulse response estimates for each transmitter-receiver pair:

$$\hat{h}_{nm}[i] = \sum_{k=0}^{31} S_{nm}[k] \exp(j \frac{2\pi i k}{32})$$

6) To increase the SNR of the channel estimates, the impulse responses are cut off at the point where the signal-to-noise+truncation power is maximized. This cutoff length k_c is:

$$k_c = \min_k (P_h[k] + k\sigma_n^2), k = k_o, \dots, 31$$

7) Append 32 zeros to the channel impulse response estimates and calculate the FFT. The FFT outputs are the desired channel estimates $\hat{H}_{nm}[k]$ for transmitter m , receiver n , and subcarrier k .

$$\hat{H}_{nm}[k] = \sum_{i=0}^{63} \hat{h}_{nmo}[i] \exp(-j \frac{2\pi i k}{64})$$

$$\hat{h}_{nmo} = \{\hat{h}_{nm}[0], \dots, \hat{h}_{nm}[31], 0, \dots, 0\}$$

Channel Variation Tracking

[0009] Channel tracking is done to improve the robustness to channel variations during a packet caused by motion of the user or changes in the environment. For 802.11a rates, a decision directed calculation can be used where, for each subcarrier of every symbol, a channel estimate $\hat{\mathbf{H}}_{ne}$ is derived from the input QAM vector $\mathbf{r}_n$ and the estimated scalar QAM value $\hat{\mathbf{x}}_n$:

$$\hat{\mathbf{H}}_{ne} = \mathbf{r}_n \hat{\mathbf{x}}_n^{-1}$$

[0010] This estimate is used to update the channel estimate by doing a first order filtering:

$$\hat{\mathbf{H}}_n = (1 - \alpha) \hat{\mathbf{H}}_{no} + \alpha \hat{\mathbf{H}}_{ne}$$

[0011] The averaging constant α should be less than 1, with a recommended value of 0.125.

[0012] For extended rates involving different data symbols transmitted simultaneously from different transmit antennas, the above technique can be used for every group of N_{tx} symbols, where N_{tx} is the number of transmit antennas. In this case, $\hat{\mathbf{H}}_{ne}$ is an N_{rx} by N_{tx} matrix with the channel coefficients for subcarrier n , $\hat{\mathbf{x}}_n$ is a square N_{tx} by N_{tx} matrix where each column contains the estimated QAM symbols transmitted in a symbol for subcarrier n , and $\mathbf{r}_n$ is a vector with N_{rx} complex values for all receivers for subcarrier n .

WHAT IS CLAIMED IS:

- 1 1. A method of channel estimation for 802.11a packets comprising:
2 receiving signals from one or more receive antennas; and
3 adaptively truncating the estimated channel impulse response to improve the
4 signal-to-noise ratio of the channel estimates.
- 1 2. A method of channel estimation for extended rate packets comprising:
2 receiving signals from multiple transmit antennas using multiple receive
3 antennas; and
4 estimating channel effects using inputs from the multiple receive antennas.
- 1 3. A method of tracking channel variations during receipt of a packet
2 using one or more receive antennas, comprising:
3 estimating a scalar QAM value;
4 deriving a per-symbol channel estimate from an input QAM vector and the
5 estimated QAM value; and
6 updating a channel estimate from a first order filtering of the per-symbol
7 channel estimates over a plurality of symbols.
- 1 4. A method of tracking channel variations throughout a packet
2 comprising:
3 receiving signals using one or more receive antennas from multiple transmit
4 antennas; and
5 generating per-symbol channel estimates representing the channel variations.

PATENT

Attorney Docket No.: 021245-000300US

CHANNEL ESTIMATION FOR IEEE 802.11A AND EXTENDED RATES

ABSTRACT OF THE DISCLOSURE

Channel estimates can be obtained for extended 802.11a rates, based on a modified preamble. An improved channel estimation technique for legacy 802.11a rates is described, as well as a way to track channel variations throughout a packet.

SF 1444841 v1

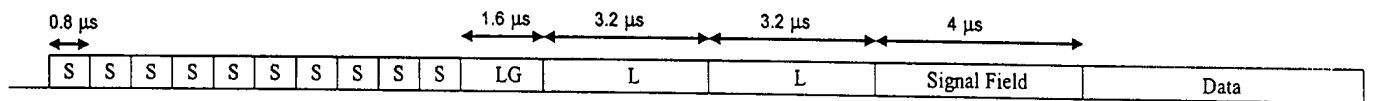


FIG. 1

$$\begin{aligned}
 L1 &= \begin{Bmatrix} 0 & 1 & -1 & -1 & 1 & 1 & -1 & 1 & -1 & 1 & -1 & -1 & -1 & -1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & -1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & 1 & -1 & 1 & 1 & 1 \end{Bmatrix} \\
 L2 &= \begin{Bmatrix} 0 & 1 & -1 & -1 & 1 & 1 & -1 & 1 & -1 & 1 & -1 & -1 & -1 & -1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & -1 & 1 & 1 & 1 & 1 & -1 & -1 & 1 & -1 \\ -1 & -1 & 1 & 1 & 1 & 1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & -1 & -1 & 1 & 1 & -1 & 1 & -1 & 1 & 1 & 1 \end{Bmatrix} \\
 L3 &= \begin{Bmatrix} 0 & 1 & -1 & -1 & -1 & -1 & 1 & -1 & -1 & 1 & -1 & -1 & 1 & 1 & 1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & 1 & -1 & 1 & 1 & 1 & -1 & 1 & 1 & -1 & 1 \\ -1 & -1 & 1 & 1 & -1 & -1 & -1 & -1 & -1 & -1 & 1 & 1 & 1 & -1 & 1 & -1 \\ 1 & 1 & 1 & 1 & -1 & 1 & 1 & -1 & 1 & -1 & 1 & -1 & -1 & -1 & -1 & -1 \end{Bmatrix}
 \end{aligned}$$

FIG. 2