



US007702028B2

(12) **United States Patent**  
**Zhou et al.**

(10) **Patent No.:** **US 7,702,028 B2**  
(45) **Date of Patent:** **Apr. 20, 2010**

(54) **METHOD OF TRANSMITTING PREAMBLE FOR SYNCHRONIZATION IN A MIMO-OFDM COMMUNICATION SYSTEM**

7,139,340 B2 \* 11/2006 Scarpa ..... 375/344

(75) Inventors: **Yong-Xing Zhou**, Yongin-si (KR);  
**Jong-Han Kim**, Suwon-si (KR)

(Continued)

**FOREIGN PATENT DOCUMENTS**

(73) Assignee: **Samsung Electronics Co., Ltd.**,  
Suwon-si (KR)

EP 1 261 181 11/2002

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 916 days.

(Continued)

**OTHER PUBLICATIONS**

(21) Appl. No.: **10/965,087**

Training sequence assisted channel estimation for MIMO OFDM by Sumei Sun; Wiemer, I.; Ho, C.K.; Tjhung, T.T.; Wireless Communications and Networking, 2003. WCNC 2003. 2003 IEEE vol. 1, Mar. 16-20, 2003 pp. 38-43 vol. 1.\*

(22) Filed: **Oct. 14, 2004**

(65) **Prior Publication Data**

(Continued)

US 2005/0084030 A1 Apr. 21, 2005

(30) **Foreign Application Priority Data**

*Primary Examiner*—David C Payne  
*Assistant Examiner*—Tanmay K Shah  
(74) *Attorney, Agent, or Firm*—NSIP Law

Oct. 16, 2003 (KR) ..... 10-2003-0072176

(51) **Int. Cl.**  
**H04B 7/02** (2006.01)

(57) **ABSTRACT**

(52) **U.S. Cl.** ..... 375/267; 370/208  
(58) **Field of Classification Search** ..... 375/299,  
375/260, 340, 316, 347, 355, 267, 262, 344,  
375/148, 367; 370/208, 210, 209, 503, 203,  
370/206, 334, 320

See application file for complete search history.

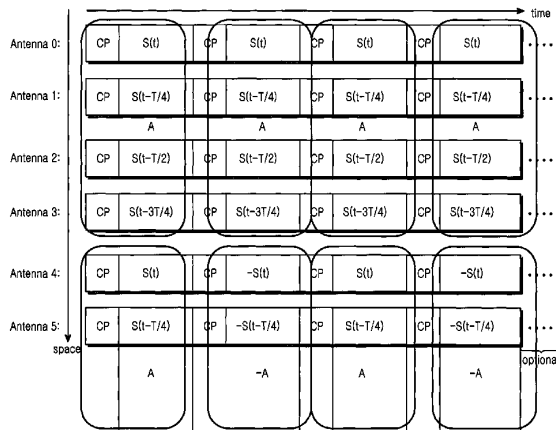
A method and apparatus for transmitting a preamble for frame synchronization and channel estimation in a MIMO-OFDM communication system are provided. An OFDM communication system using Q transmit antennas generates a base preamble sequence including a CP and an orthogonal sequence. If  $Q \leq M$  a predetermined number M, a preamble sequence for a kth antenna is  $S(t-(k-1)T/M)$ . If  $Q > M$  and  $k \leq M$  the preamble sequence transmitted for the kth antenna is  $S(t-(k-1)T/M)$ . If  $Q > M$  and  $k > M$ , the preamble sequence for the kth antenna is  $(-1)^{(P_{S-1})} S(t-(k-M-1)T/M)$ . Here, S(t) is the orthogonal sequence, T is the period of the orthogonal sequence, and PS is an index indicating a transmission period of the preamble sequence. The preamble sequences are at least twice transmitted from the Q transmit antennas.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

6,226,337 B1 \* 5/2001 Klank et al. .... 375/367  
6,377,632 B1 \* 4/2002 Paulraj et al. .... 375/299  
6,731,614 B1 \* 5/2004 Ohlson et al. .... 370/320  
7,061,854 B2 \* 6/2006 Tarokh et al. .... 370/206  
7,068,628 B2 \* 6/2006 Li et al. .... 370/334  
7,136,410 B2 \* 11/2006 Choi et al. .... 375/148  
7,139,320 B1 \* 11/2006 Singh et al. .... 375/260

**14 Claims, 14 Drawing Sheets**



U.S. PATENT DOCUMENTS

7,154,964	B1 *	12/2006	Al-Dhahir et al. ....	375/299
7,184,495	B2 *	2/2007	Thomson et al. ....	375/340
7,263,058	B2 *	8/2007	Joo .....	370/203
7,269,127	B2 *	9/2007	Mody et al. ....	370/210
2002/0181390	A1 *	12/2002	Mody et al. ....	370/208
2003/0016621	A1	1/2003	Li	
2003/0043887	A1 *	3/2003	Hudson .....	375/144
2004/0050022	A1 *	3/2004	Marrecau et al. ....	55/282.3
2004/0071234	A1 *	4/2004	Li .....	375/341
2004/0081131	A1 *	4/2004	Walton et al. ....	370/344
2004/0131011	A1 *	7/2004	Sandell et al. ....	370/210
2004/0131012	A1 *	7/2004	Mody et al. ....	370/210

FOREIGN PATENT DOCUMENTS

WO	WO 02/098088	12/2002
----	--------------	---------

OTHER PUBLICATIONS

Fast burst systems synchronisation technique for OFDM-WLAN by B.Y. Prasetyo, F.Said and AH. Aghvami. Communications, IEE Proceedings- vol. 147, Issue 5, Oct. 2000 pp. 292-298.\*

Effect of frame synchronization errors on pilot-aided channel estimation in OFDM: analysis and solution by Mostofi, Y.; Cox, D.C.; Bahai, A.;Wireless Personal Multimedia Communications, 2002. The 5th International Symposium on vol. 3, Oct. 27-30, 2002 pp. 1309-1313 vol. 3.\*

Ye Li, Simplified Channel Estimation for OFDM Systems with Multiple Transmit Antennas, IEEE Transactions on Wireless Communications, vol. 1, No. 1, Jan. 2002, pp. 67-75.

Imad Barhumi et al., Optimal Training Design for MIMO OFDM Systems in Mobile Wireless Channels, IEEE Transactions on Signal Processing, vol. 51, No. 6, Jun. 2003, pp. 1615-1624.

Apurva N. Mody et al., Receiver Implementation for a MIMO OFDM System, IEEE Global Telecommunications Conference, Nov. 2002, pp. 716-720.

\* cited by examiner

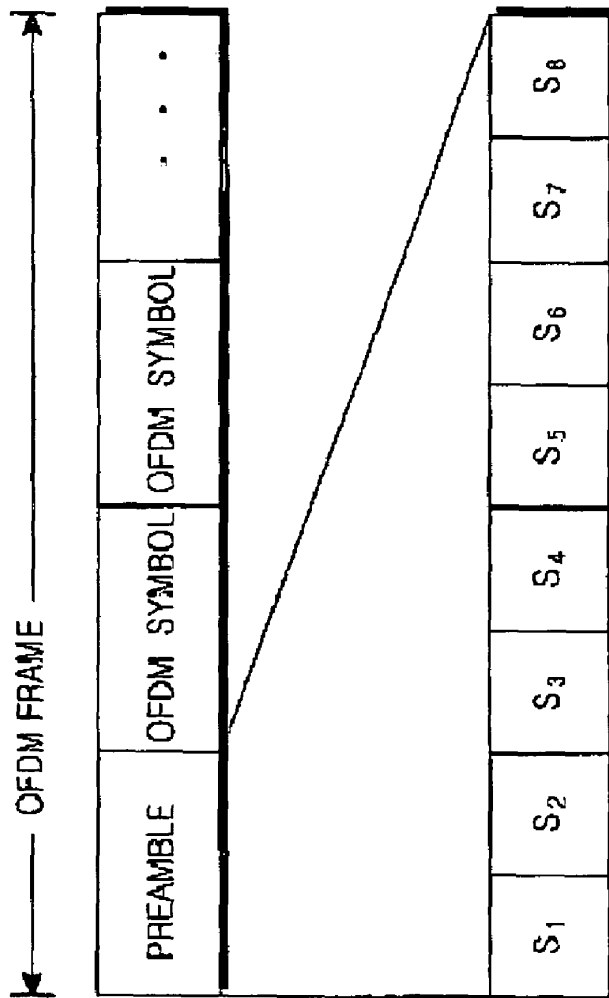


FIG.1  
(PRIOR ART)

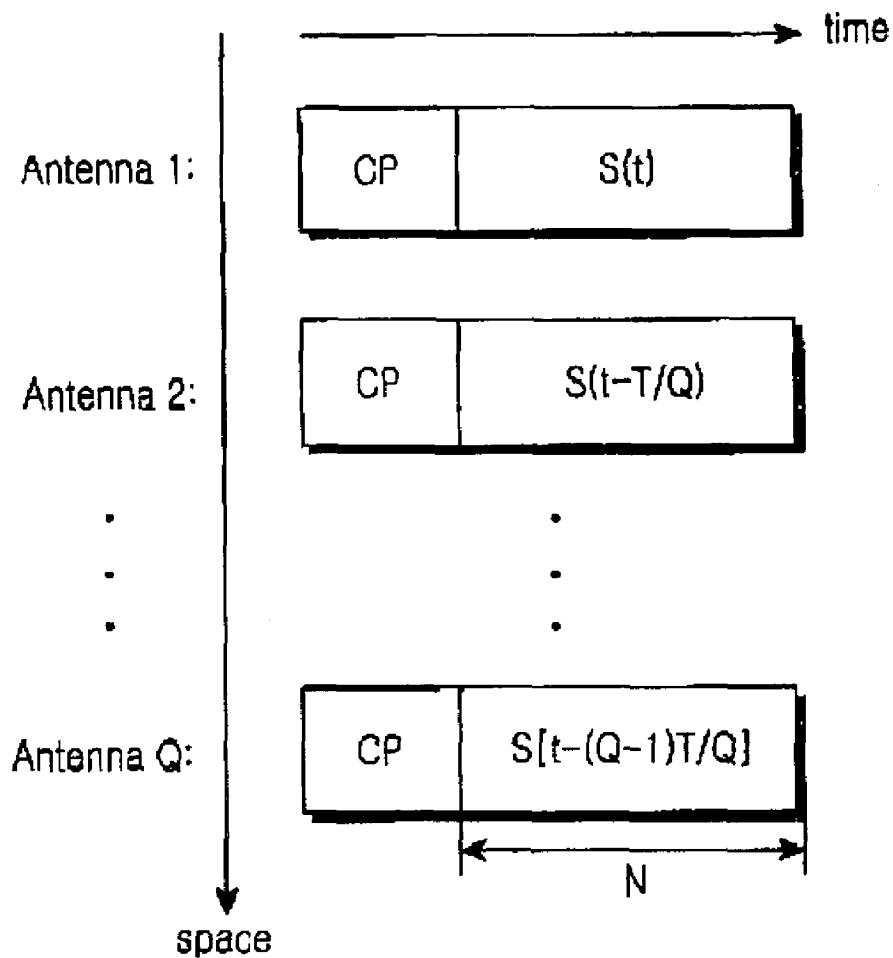


FIG.2  
(PRIOR ART)

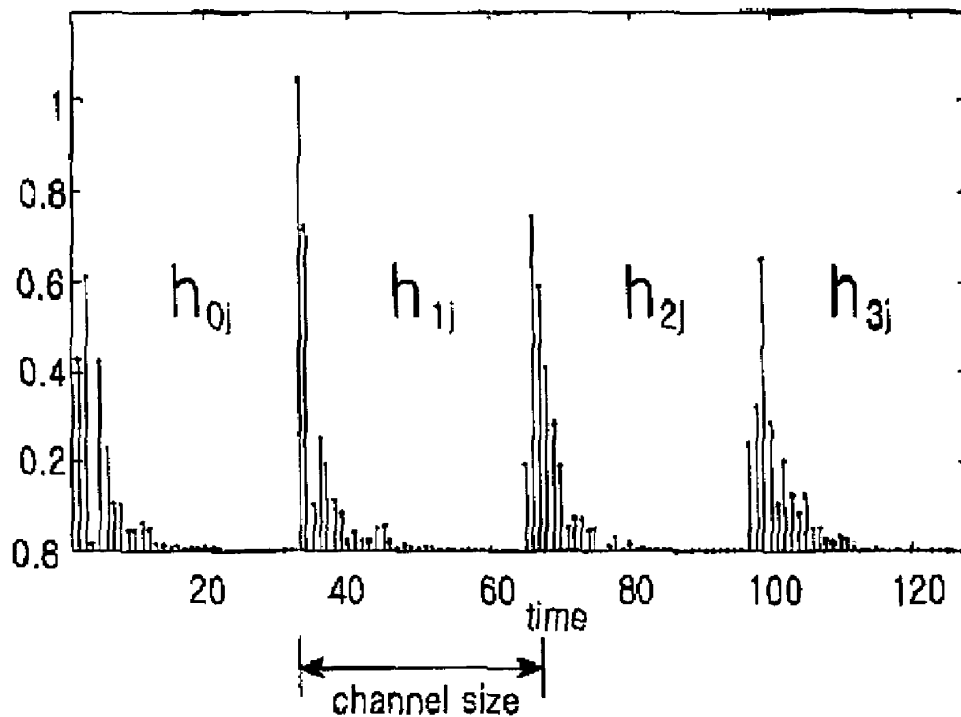


FIG.3  
(PRIOR ART)

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.