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Zhou et al.

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

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

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(Continued)

FOREIGN PATENT DOCUMENTS

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Suwon-si (KR)

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(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.*

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

(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

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 $(-1)^{(PS-1)}S(t-(k-M-1)T/M)$. 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.

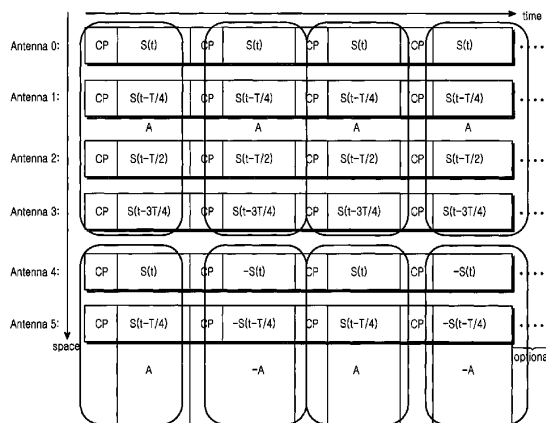
See application file for complete search history.

(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
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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

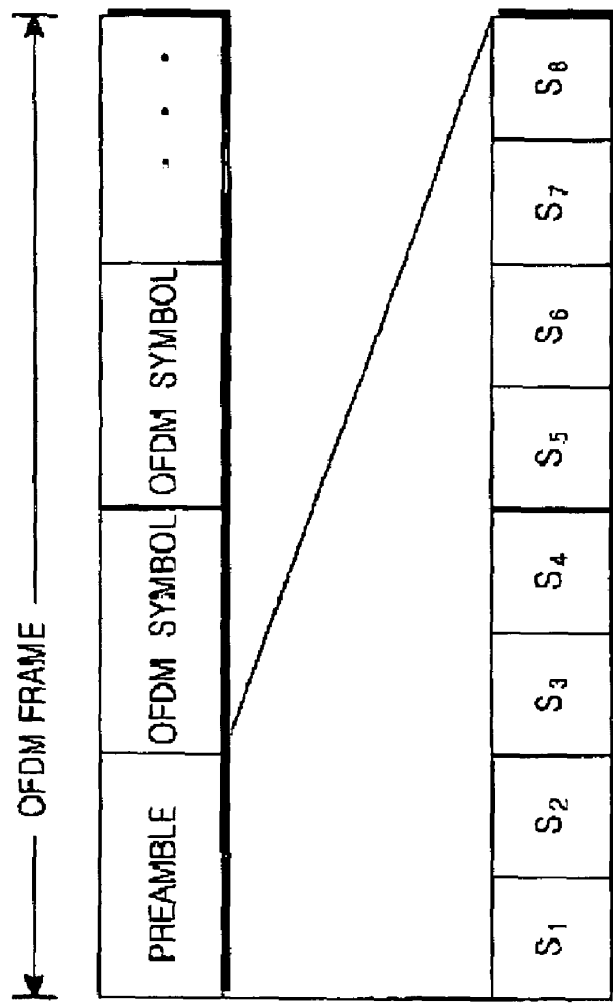


FIG.1
(PRIOR ART)

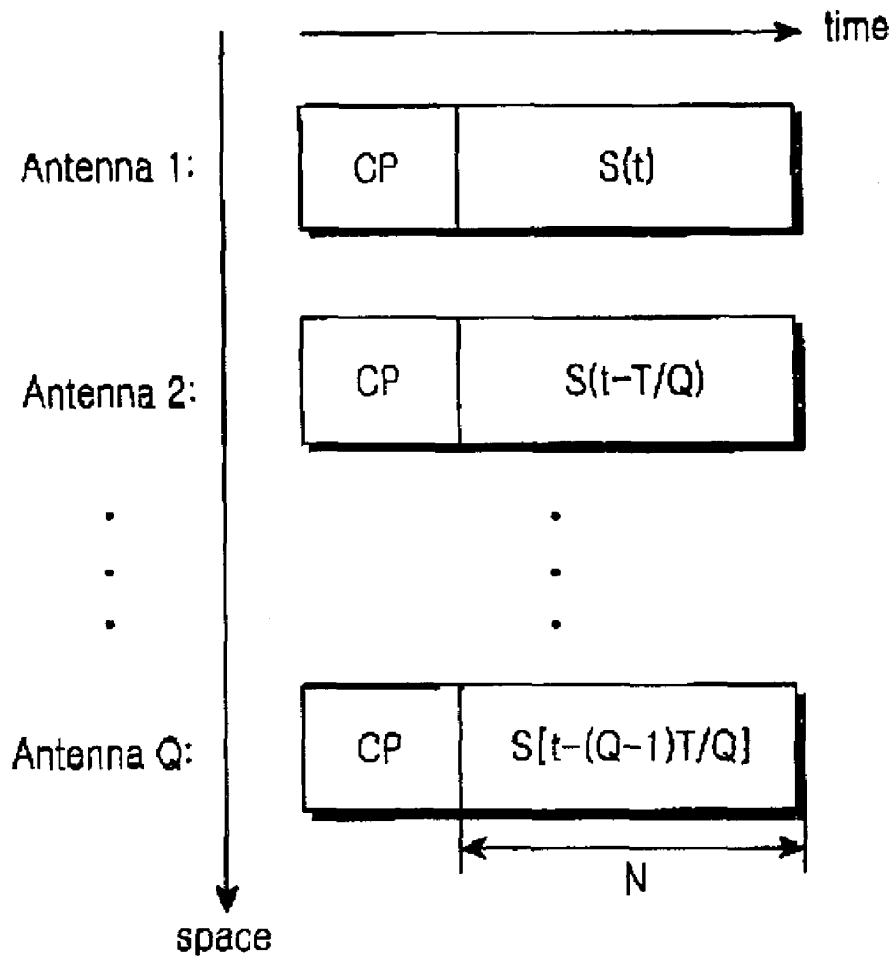


FIG.2
(PRIOR ART)

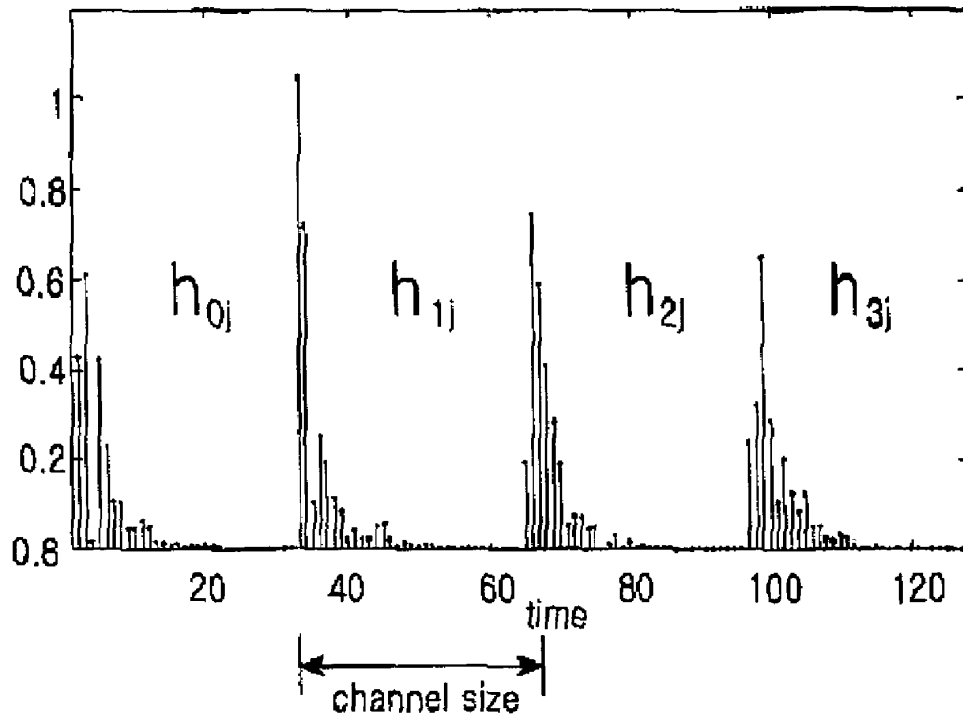


FIG.3
(PRIOR ART)

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