



US007577085B1

(12) **United States Patent**
Narasimhan

(10) **Patent No.:** **US 7,577,085 B1**
(45) **Date of Patent:** **Aug. 18, 2009**

- (54) **MULTICARRIER TRANSMIT DIVERSITY** 6,424,679 B1 * 7/2002 Dabak et al. 375/267
- 6,442,214 B1 * 8/2002 Boleskei et al. 375/299
- (75) Inventor: **Ravi Narasimhan**, Los Altos, CA (US) 6,501,803 B1 * 12/2002 Alamouti et al. 375/265
- 6,731,668 B2 * 5/2004 Ketchum 370/209
- (73) Assignee: **Marvell International Ltd.**, Hamilton (BM) 7,002,900 B2 * 2/2006 Walton et al. 370/208

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 982 days.

(Continued)

- (21) Appl. No.: **10/189,385**
- (22) Filed: **Jul. 5, 2002**

OTHER PUBLICATIONS

Lee, King, A space frequency transmitter diversity technique for OFDM systems, Dec. 1, 2000, IEEE, pp. 1473-1477.*

(Continued)

Related U.S. Application Data

- (63) Continuation of application No. 10/162,274, filed on Jun. 3, 2002, now abandoned.

Primary Examiner—Steven H Nguyen

(57) **ABSTRACT**

- (51) **Int. Cl.**
 - H04J 11/00** (2006.01)
 - H04B 7/216** (2006.01)
 - H04B 7/02** (2006.01)
 - H04B 15/00** (2006.01)
 - H04K 1/10** (2006.01)
 - H04B 7/10** (2006.01)
- (52) **U.S. Cl.** **370/206; 370/335; 370/342; 375/260; 375/267; 375/285; 375/299; 375/347**
- (58) **Field of Classification Search** **370/203–210, 370/335, 342; 375/260, 267, 285, 299, 347**
See application file for complete search history.

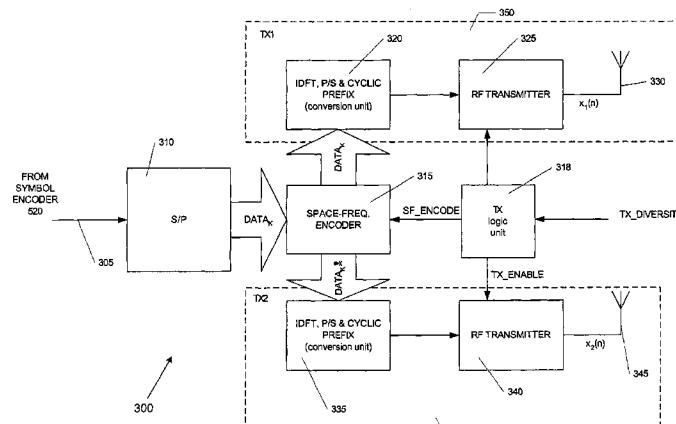
Method, apparatus, and data packet format to implement transmit diversity in a multicarrier environment is disclosed. For diversity transmission operations, space frequency encoding techniques are employed creating distinguishable first and second time domain signals from a multicarrier frequency domain symbol bearing data of interest, which are then broadcast in parallel over first and second transmission units respectively. For diversity reception operations, complementary space frequency decoding is used to recover a corrected multicarrier frequency domain symbol from a time domain signal containing either this symbol, a space frequency modified symbol based on the multicarrier symbol, or a possible partial/complete combination of both. The data packet format includes portions defining a transmission diversity semaphore, a preamble enabling training of a receiver receiving the data packet, and a payload. This payload includes plural data symbol pairs, each defining a first symbol for transmission by a first transmission unit of a diversity transmitter, and a second symbol for transmission by a second transmission unit of the diversity transmitter, the second symbol being derived from the first symbol.

(56) **References Cited**

U.S. PATENT DOCUMENTS

- 5,598,419 A 1/1997 Weigand et al. 370/514
- 5,668,813 A 9/1997 Malek et al. 370/514
- 5,729,543 A 3/1998 Weigand et al. 370/347
- 5,745,484 A 4/1998 Scott 370/347
- 5,822,308 A 10/1998 Weigand et al. 370/280
- 6,031,833 A 2/2000 Fickes et al. 370/349
- 6,122,267 A 9/2000 Abiven et al. 370/338
- 6,144,711 A * 11/2000 Raleigh et al. 375/347
- 6,185,258 B1 * 2/2001 Alamouti et al. 375/260
- 6,351,499 B1 * 2/2002 Paulraj et al. 375/267

62 Claims, 6 Drawing Sheets



U.S. PATENT DOCUMENTS

7,020,072	B1 *	3/2006	Li et al.	370/208
7,065,036	B1 *	6/2006	Ryan	370/208
7,088,785	B2 *	8/2006	Nafie et al.	375/267
7,149,253	B2 *	12/2006	Hosur	375/267
2002/0131516	A1 *	9/2002	El-Gamal et al.	375/285
2003/0072258	A1 *	4/2003	Tarokh et al.	370/210

OTHER PUBLICATIONS

Peichocki R. Performance of space time coding with hiperlan/2 and IEEE 802.11a wlan standards on real channels, Oct. 11, 2001; pp. 848-852.*

Peichocki R. Performance of space frequency techniques over measured channels in MIMO-Systems, Oct. 11, 2001; pp. 1-9.*

IEEE P802.11/g/D8.2, Apr. 2003 (Supplement to ANSI/IEEE std 802.11 1999(Reaff2003), *Sponsory LAN MAN Standards Committee of IEEE Computer Society*, "Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Further Higher Data Rate Extension in the 2.4 GHz Band," pp. 1-69.

Alamouti, Siavash M., "A Simple Transmit Diversity Technique for Wireless Communications", *IEEE Journal on Select Areas in Communications*, vol. 6, No. 8, Oct. 1998, pp. 1451-1457.

IEEE std. 802.11a—1999, *Sponsor LAN MAN Standards Committee of IEEE Computer Society*, "Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, High-Speed Physical Layer Extension in the 5 GHz Band," Sep. 1999, pp. 1-83.

IEEE std. 802.11b—1999, *Sponsor LAN MAN Standards Committee of IEEE Computer Society*, "Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, Higher-Speed Physical Layer Extension in 2.4 GHz Band," Sep. 1999, pp. 1-89.

International Standard, ANSI/IEEE std. 802.11, first edition, *Sponsor LAN MAN Standards Committee of IEEE Computer Society*, "Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications," 1999.

* cited by examiner

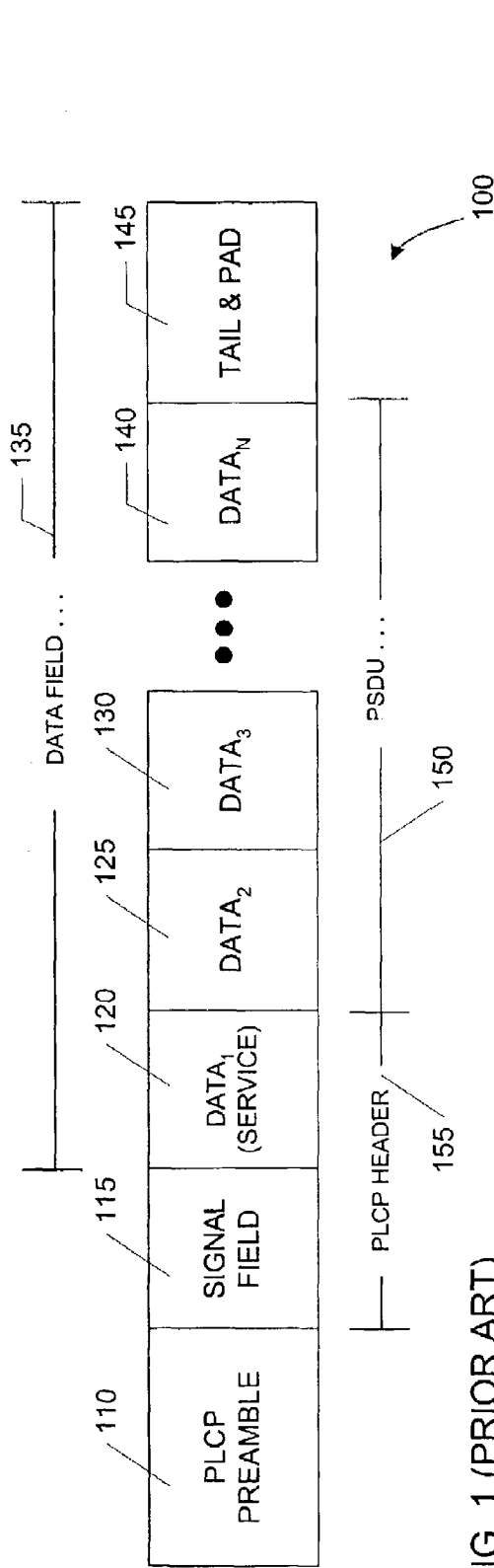


FIG. 1 (PRIOR ART)

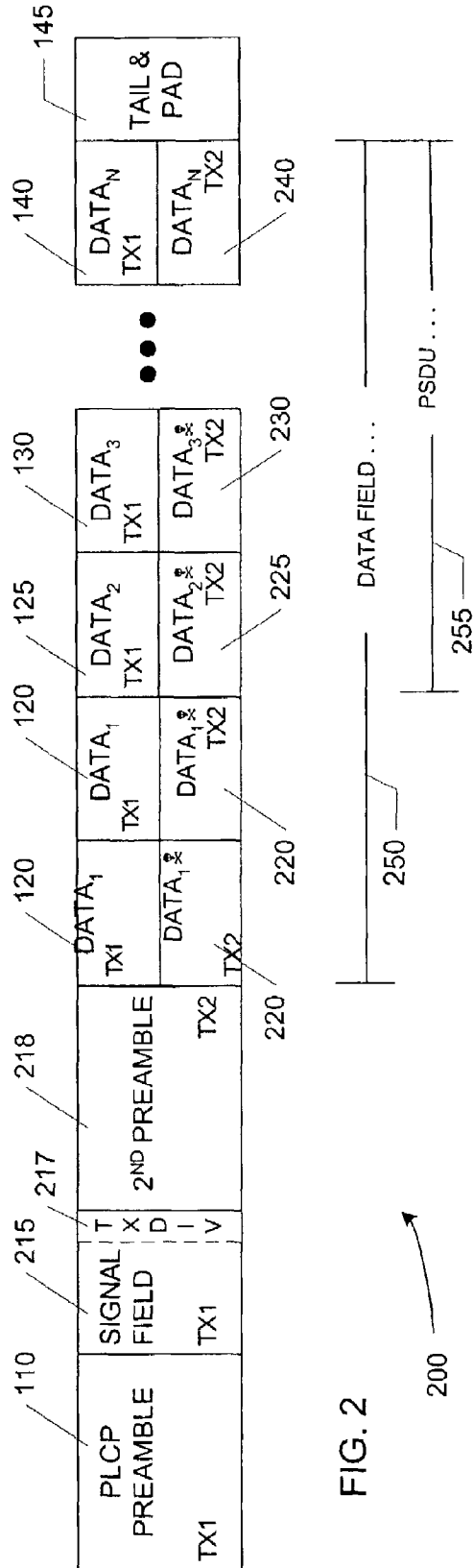


FIG. 2

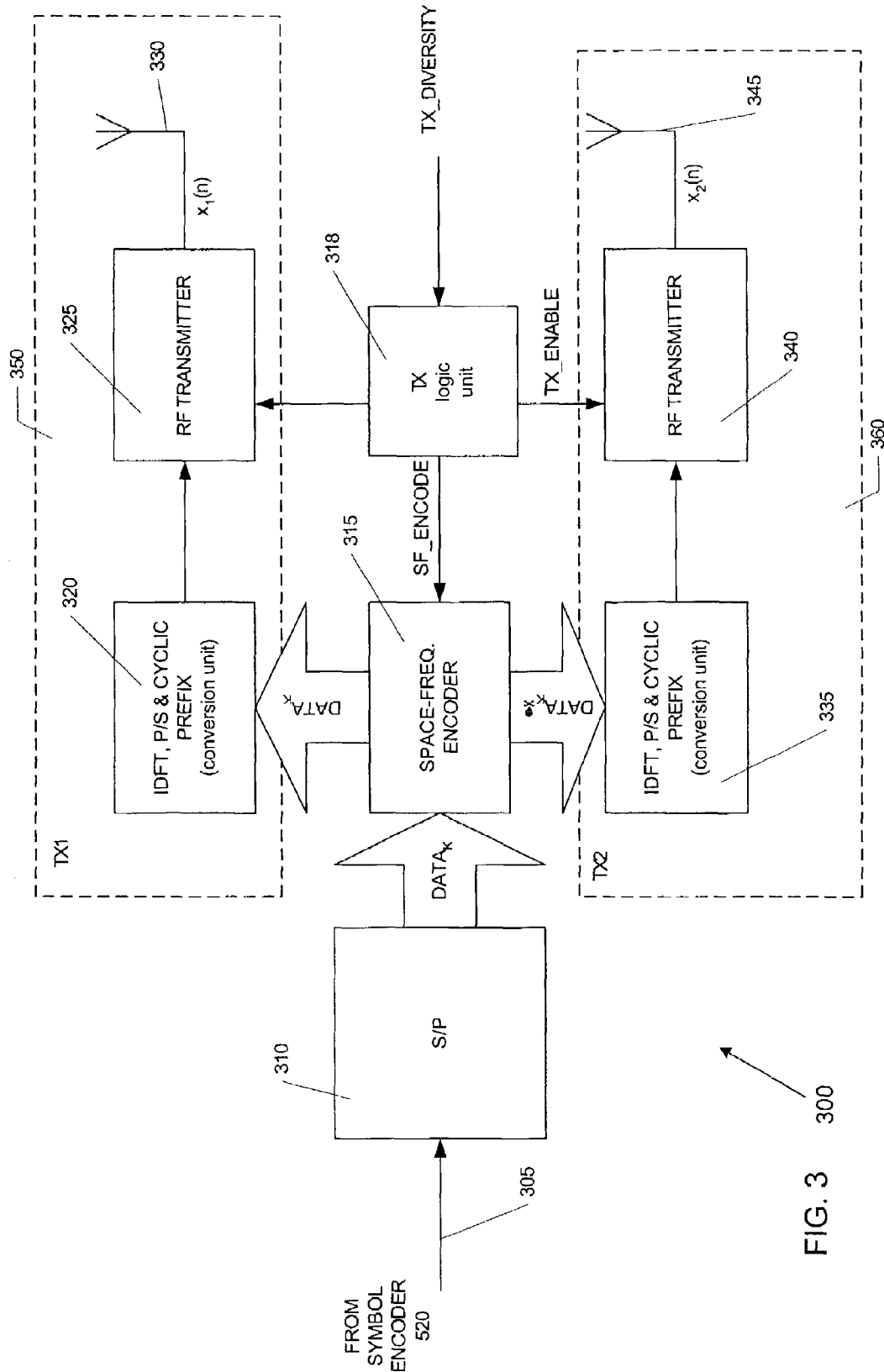


FIG. 3 300

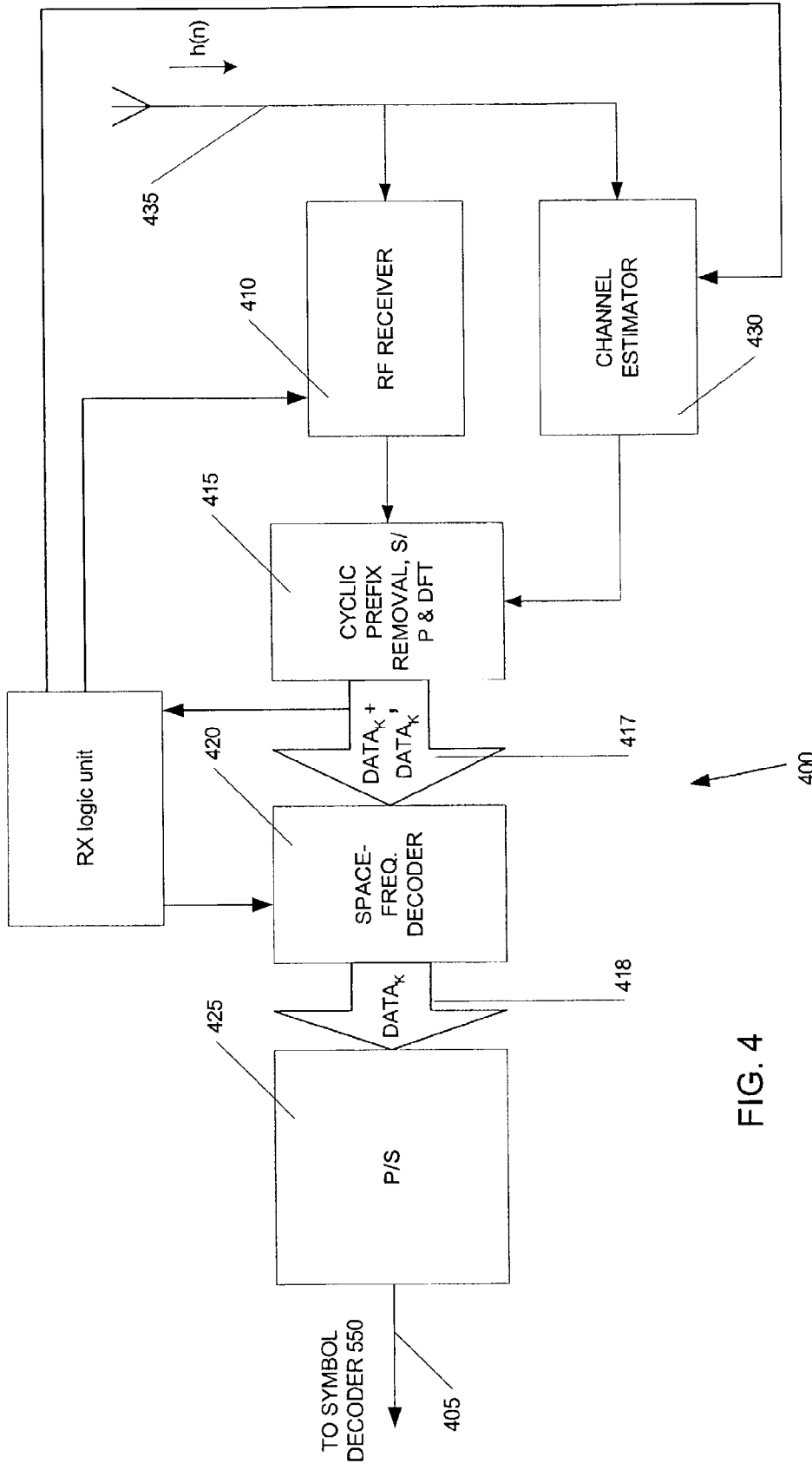


FIG. 4

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.