

# EXHIBIT D



US008416862B2

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

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(45) **Date of Patent:** **Apr. 9, 2013**

(54) **EFFICIENT FEEDBACK OF CHANNEL INFORMATION IN A CLOSED LOOP BEAMFORMING WIRELESS COMMUNICATION SYSTEM**

2003/0139196 A1\* 7/2003 Medvedev et al. .... 455/522  
2004/0042558 A1\* 3/2004 Hwang et al. .... 375/267  
2005/0286663 A1\* 12/2005 Poon ..... 375/347

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OTHER PUBLICATIONS  
A unified algebraic transformation approach for parallel recursive and adaptive filtering and SVD algorithms Jun Ma; Parhi, K.K.; Deprettere, E.F.; Signal Processing, IEEE Transactions on [see also Acoustics, Speech, and Signal Processing, IEEE Transactions on] vol. 49, Issue 2, Feb. 2001 pp. 424-437.\*

(73) Assignee: **Broadcom Corporation**, Irvine, CA (US)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 2247 days.

\* cited by examiner

(21) Appl. No.: **11/237,341**

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(22) Filed: **Sep. 28, 2005**

(74) *Attorney, Agent, or Firm* — Garlick & Markison; Holly L. Rudnick

(65) **Prior Publication Data**

US 2006/0239374 A1 Oct. 26, 2006

(57) **ABSTRACT**

**Related U.S. Application Data**

(63) Continuation-in-part of application No. 11/168,793, filed on Jun. 28, 2005.

A method for feeding back transmitter beamforming information from a receiving wireless communication device to a transmitting wireless communication device includes a receiving wireless communication device receiving a preamble sequence from the transmitting wireless device. The receiving wireless device estimates a channel response based upon the preamble sequence and then determines an estimated transmitter beamforming unitary matrix based upon the channel response and a receiver beamforming unitary matrix. The receiving wireless device then decomposes the estimated transmitter beamforming unitary matrix to produce the transmitter beamforming information and then wirelessly sends the transmitter beamforming information to the transmitting wireless device. The receiving wireless device may transform the estimated transmitter beamforming unitary matrix using a QR decomposition operation such as a Givens Rotation operation to produce the transmitter beamforming information.

(60) Provisional application No. 60/673,451, filed on Apr. 21, 2005, provisional application No. 60/698,686, filed on Jul. 13, 2005.

(51) **Int. Cl.**  
**H04K 1/10** (2006.01)

(52) **U.S. Cl.** ..... 375/260; 375/267; 375/350

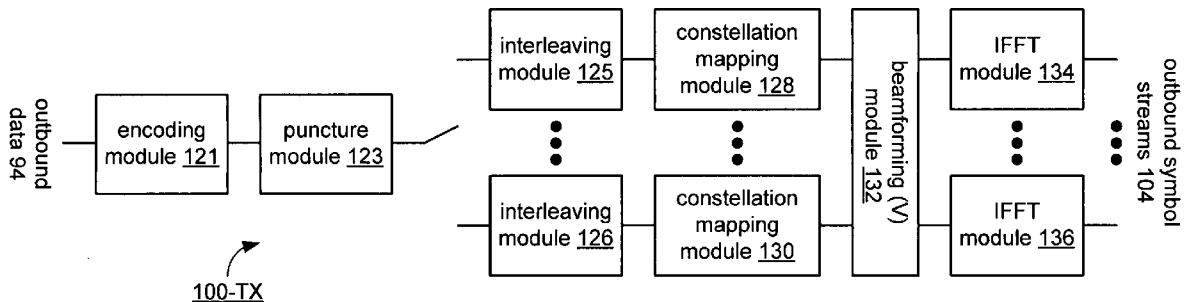
(58) **Field of Classification Search** ..... 375/267  
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,541,607 A \* 7/1996 Reinhardt ..... 342/372  
2002/0187753 A1\* 12/2002 Kim et al. .... 455/69

**20 Claims, 8 Drawing Sheets**



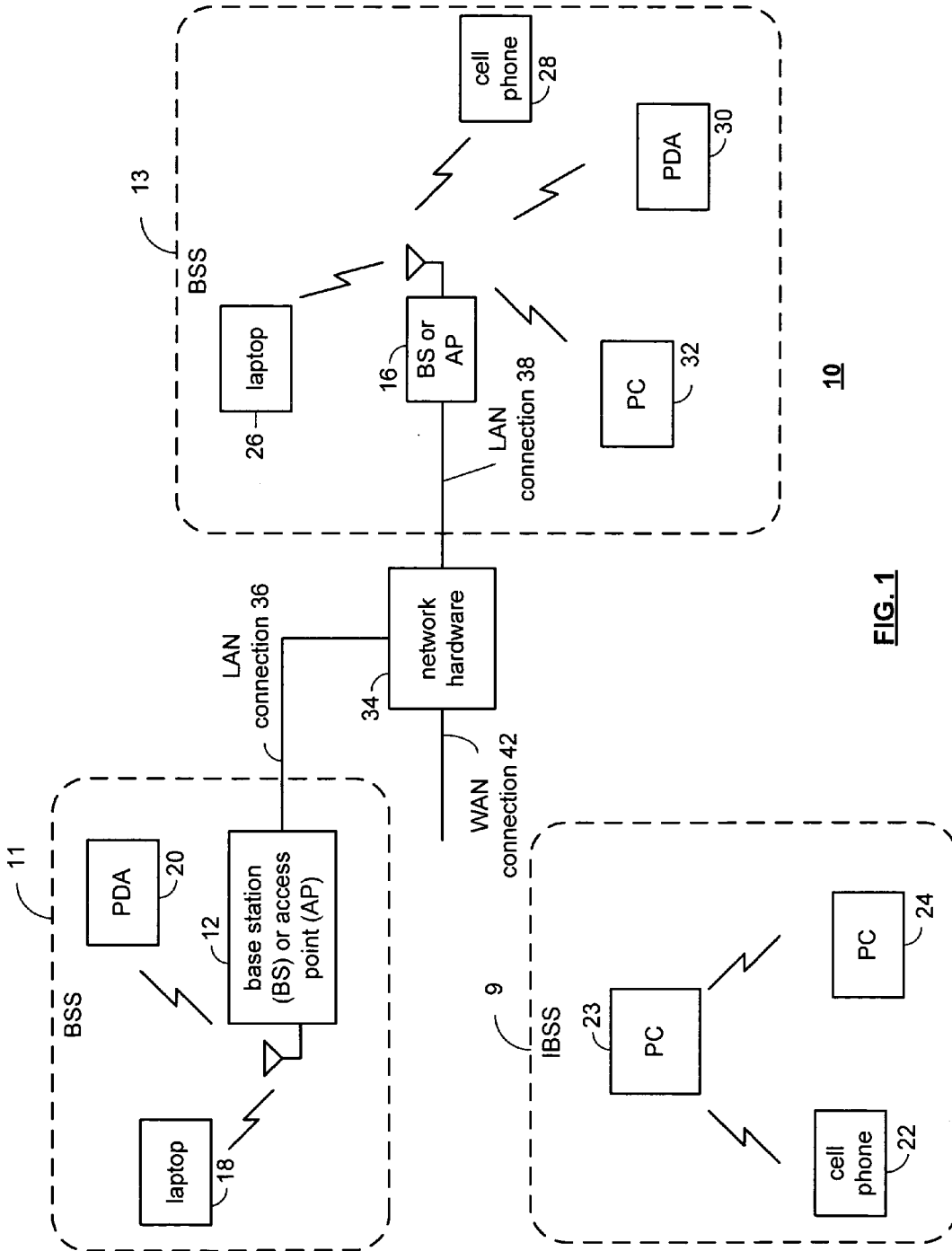


FIG. 1

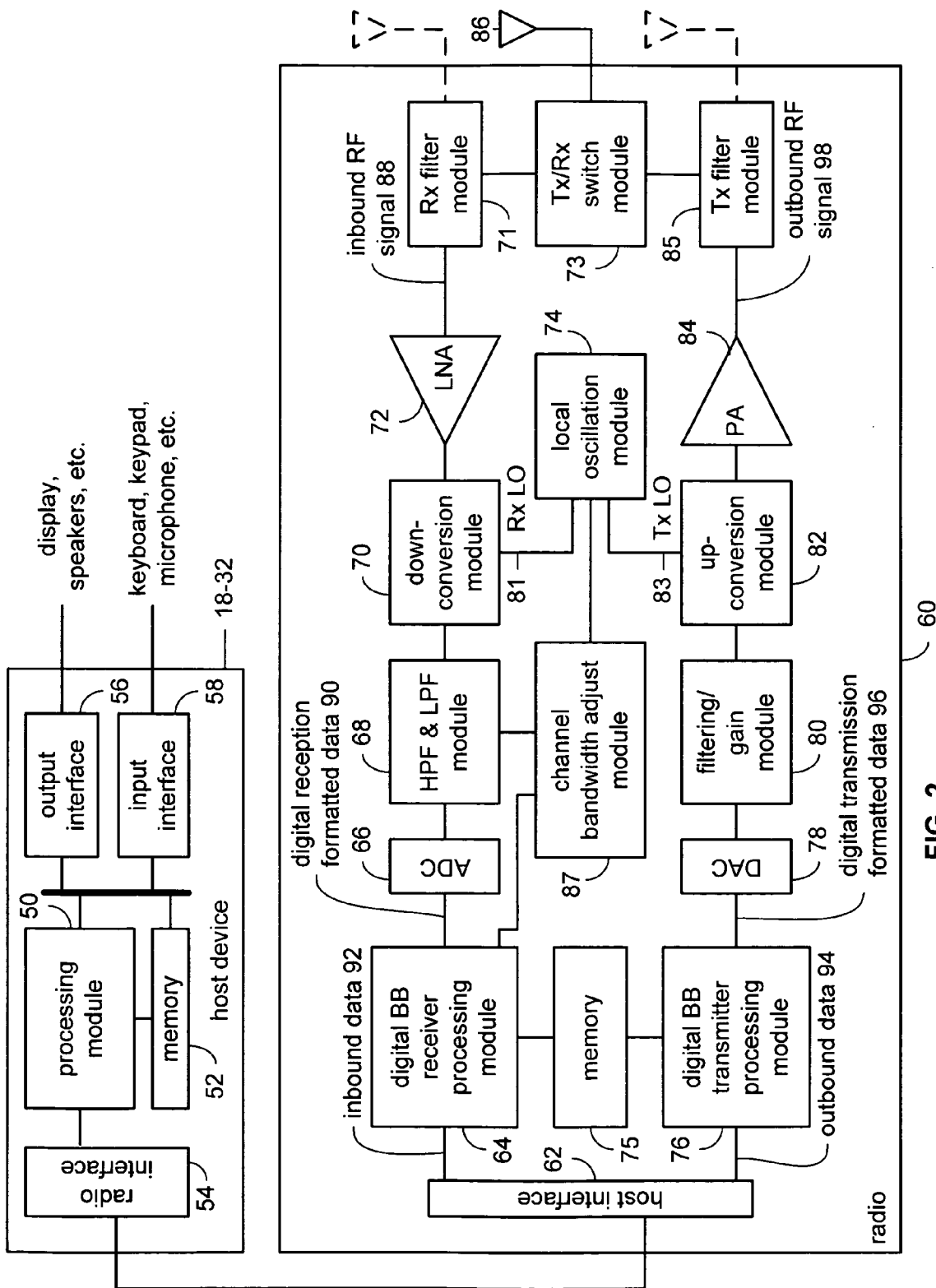
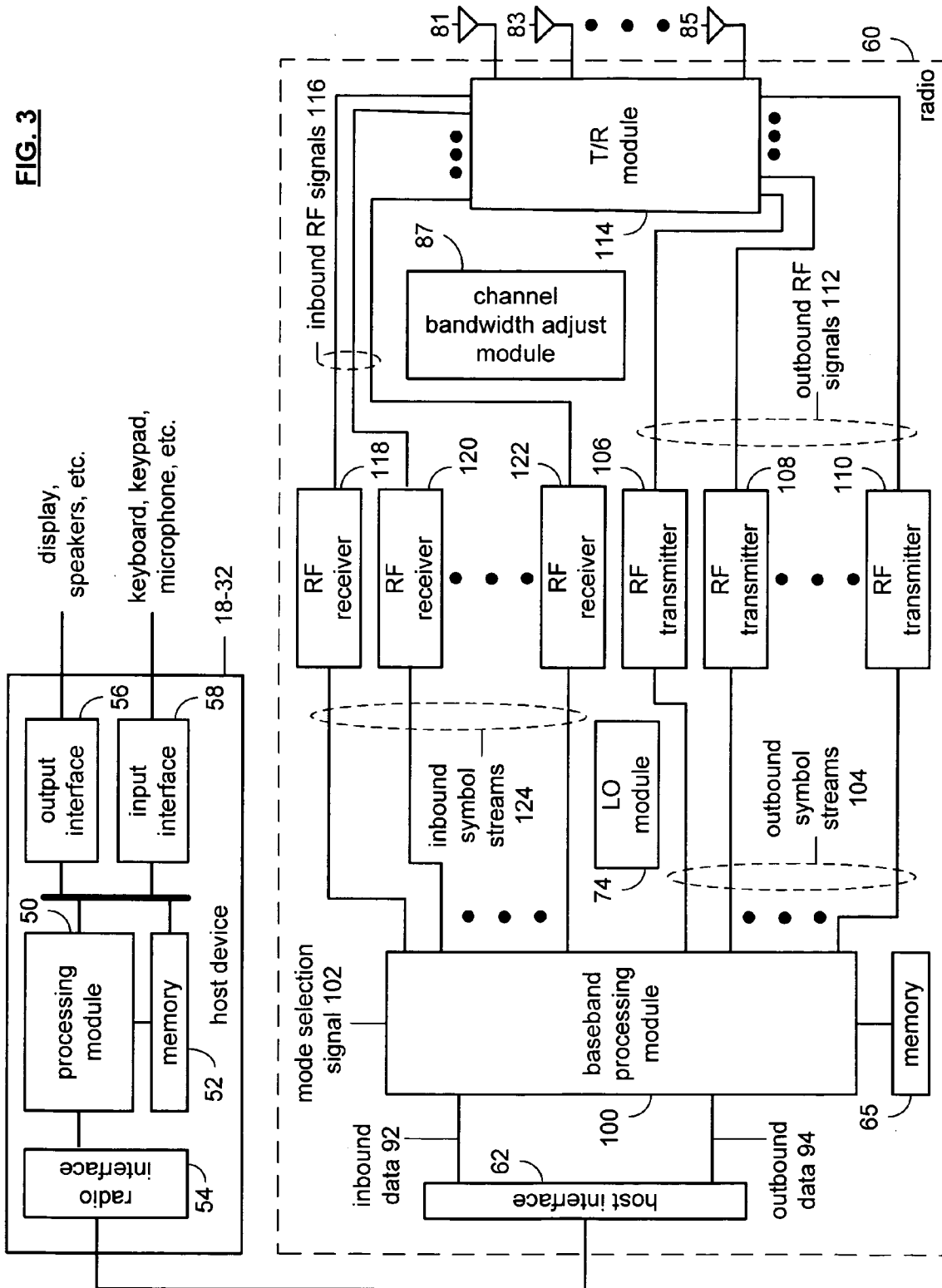


FIG. 2

FIG. 3



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