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# United States Patent [19]

[11] **Patent Number:** **6,144,695**

**Helms et al.**

[45] **Date of Patent:** **Nov. 7, 2000**

[54] **METHOD AND APPARATUS FOR REDUCING NEAR-END CROSSTALK (NEXT) IN DISCRETE MULTI-TONE MODULATOR/ DEMODULATORS**

|           |         |                      |         |
|-----------|---------|----------------------|---------|
| 5,887,032 | 3/1999  | Cioffi .....         | 375/257 |
| 5,970,088 | 10/1999 | Chen .....           | 375/222 |
| 6,009,122 | 12/1999 | Chow .....           | 375/260 |
| 6,014,412 | 1/2000  | Wiese et al. ....    | 375/346 |
| 6,044,107 | 3/2000  | Gatherer et al. .... | 375/222 |

[75] Inventors: **Howard David Helms**, Brookside; **Robert Raymond Miller, II**, Township of Morris, Morris County; **Richard Robert Shively**, Convent Station, all of N.J.

### OTHER PUBLICATIONS

American National Standards Institute, Standards Document—T1.413—1995; “Network and Customer Installation Interfaces—Asymmetric Digital Subscriber Line (ADSL) Metallic Interface”; Approved Aug. 18, 1995, pp.: cover page; two inside sheets; i–vi; 1–115.

[73] Assignee: **AT&T Corp.**, New York, N.Y.

*Primary Examiner*—Stephen Chin  
*Assistant Examiner*—Michael W. Maddox

[21] Appl. No.: **08/997,176**

### [57] ABSTRACT

[22] Filed: **Dec. 23, 1997**

[51] **Int. Cl.**<sup>7</sup> ..... **H04B 1/38**; H04B 15/00; H04L 5/16

This invention reduces near-end crosstalk between identical discrete multi-tone (DMT-type) modems by introducing the following modifications to modems at a central office or a subscriber premises. The modifications include: a mechanism for aligning the frames of all modems at the central office (CO), a mechanism for aligning the frames transmitted by the subscribers' modems with the frames received by those modems, and lengthening the DMT frame to include a cyclic prefix. The cyclic prefix to a frame has been made longer than twice the maximum round-trip delay, that is, the delay between the central office and the most distant subscriber to be served. By making adjacent DMT carrier frequencies be orthogonal to each other, the aforementioned modifications will reduce both Near End Cross-Talk (NEXT) and Leakage-Excited Cross-Talk (LEXT). These benefits apply to modems at both the central office (CO) and subscriber ends of the communication path (for example, a high capacity twisted-pair wire).

[52] **U.S. Cl.** ..... **375/222**; 375/285; 375/346; 370/201; 370/480; 370/503; 379/93.01; 379/93.08; 379/406; 379/410; 379/417; 455/295; 455/501

[58] **Field of Search** ..... 375/222, 285, 375/346, 356; 370/201, 286, 480, 503, 514, 515; 379/399, 406, 410, 416, 417, 90.01, 93.01, 93.08; 455/3.1, 5.1, 501, 502, 295

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**26 Claims, 7 Drawing Sheets**

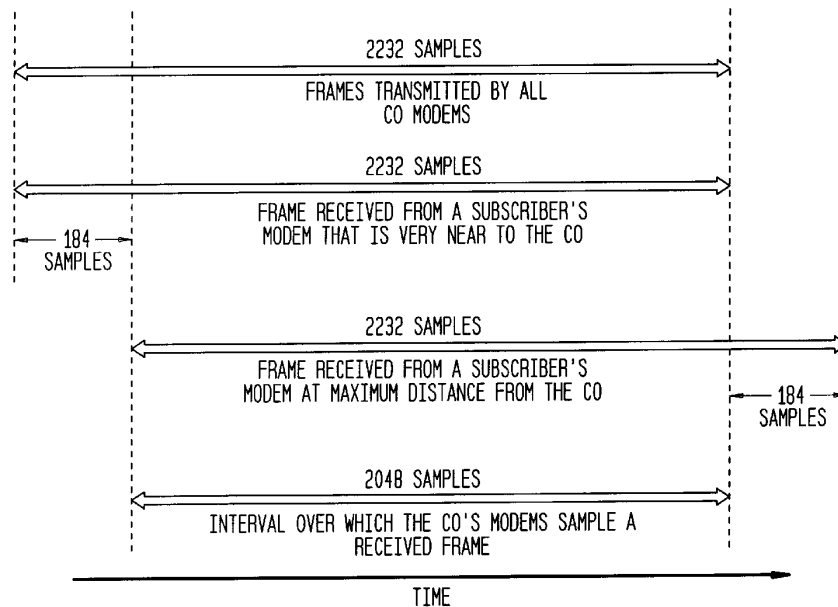


FIG. 1  
(PRIOR ART)

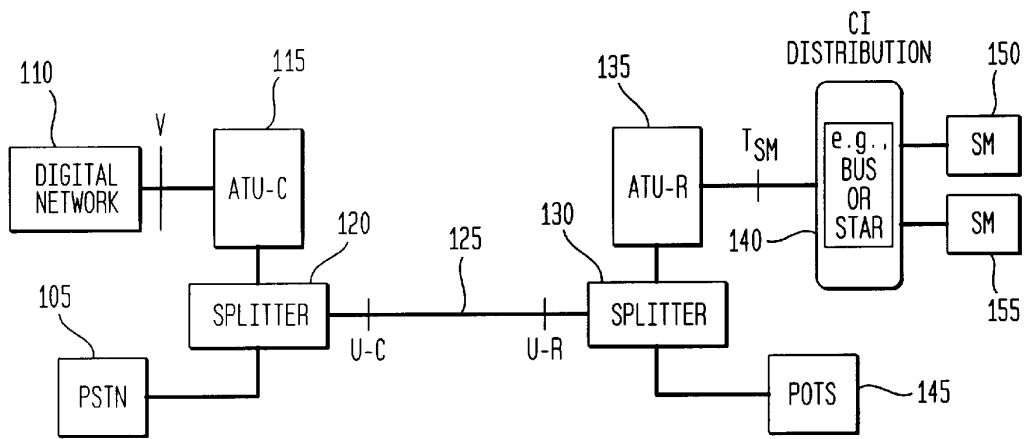


FIG. 2A  
(PRIOR ART)

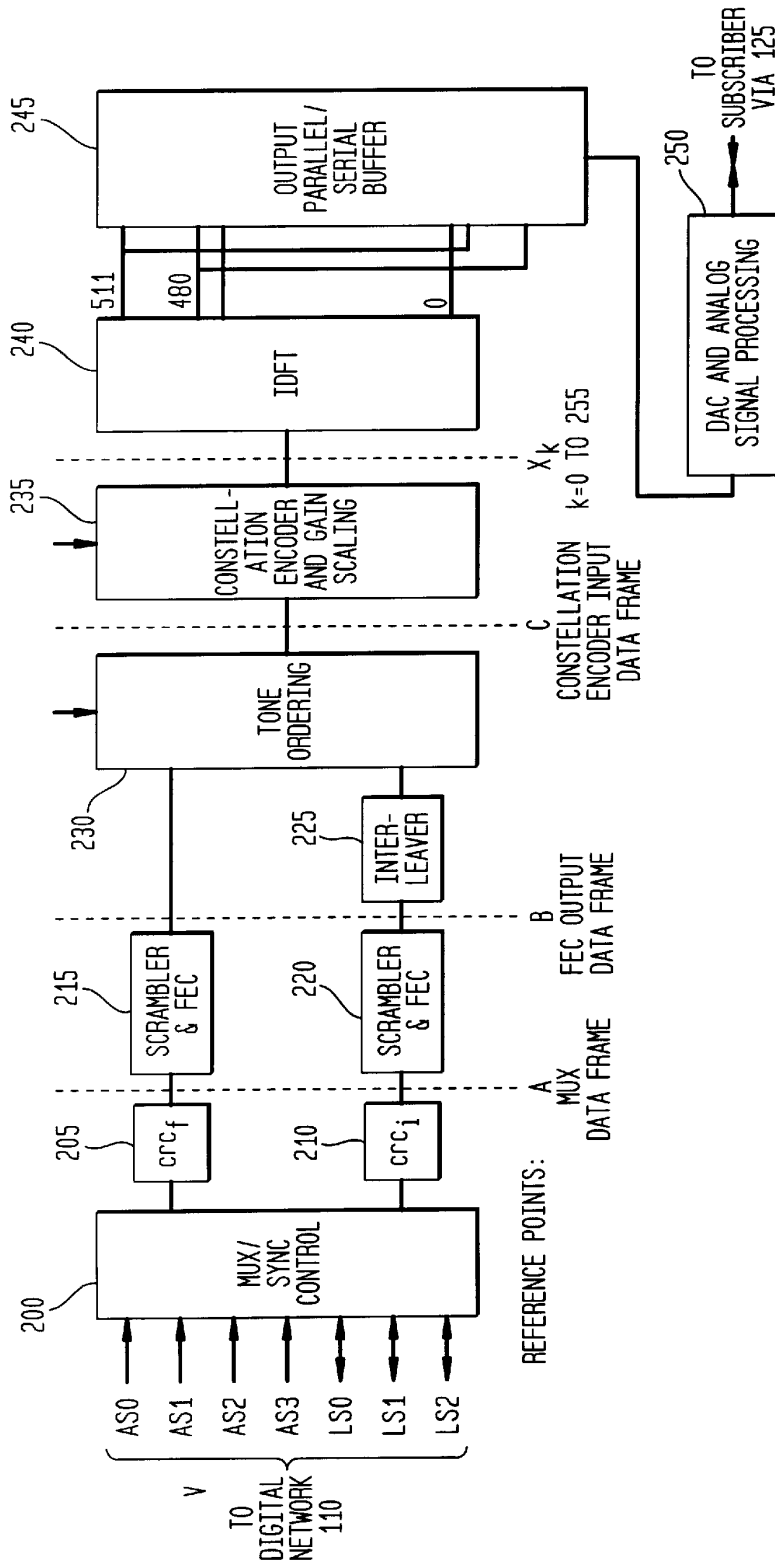


FIG. 2B  
(PRIOR ART)

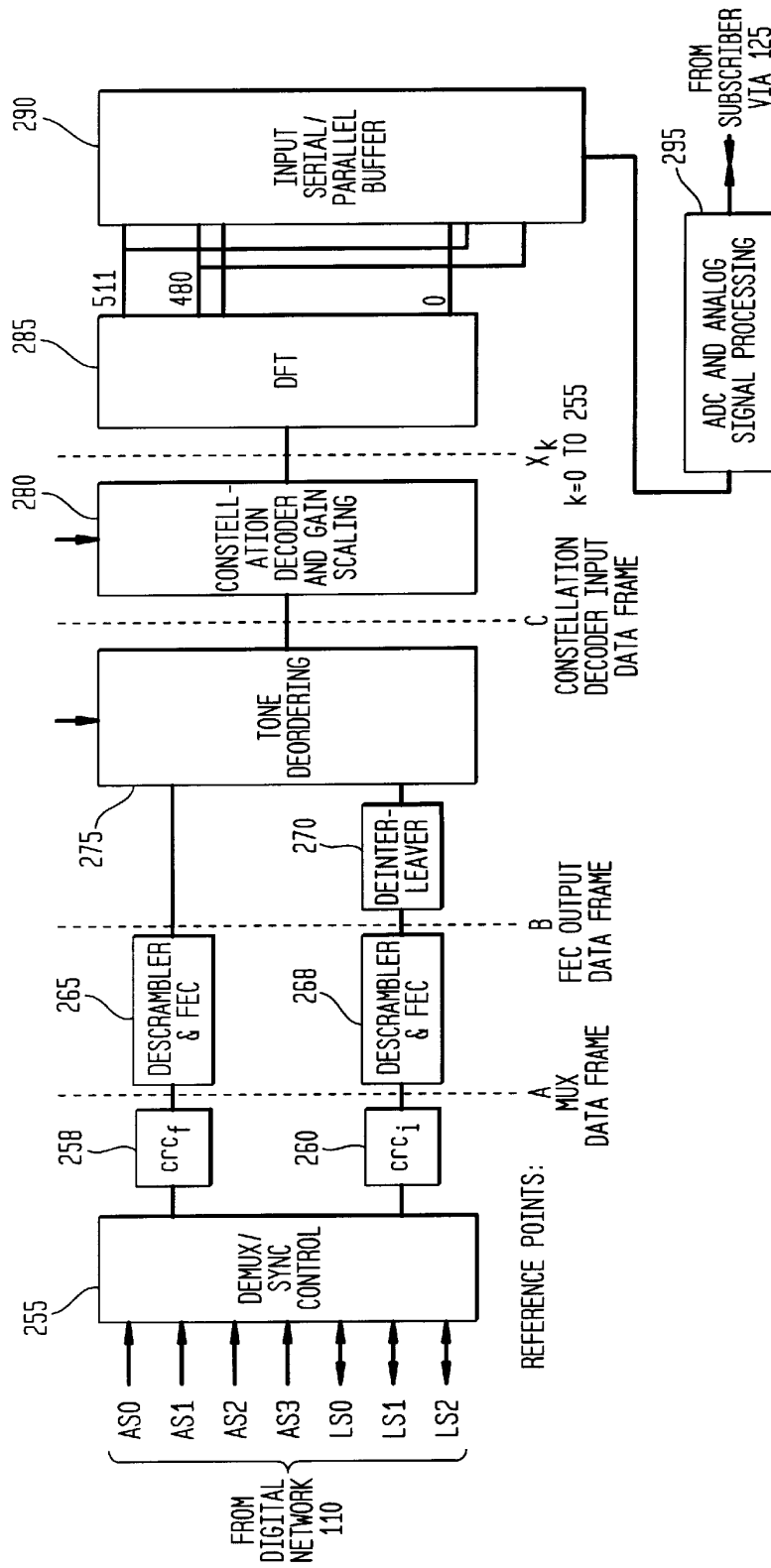


FIG. 3  
(PRIOR ART)

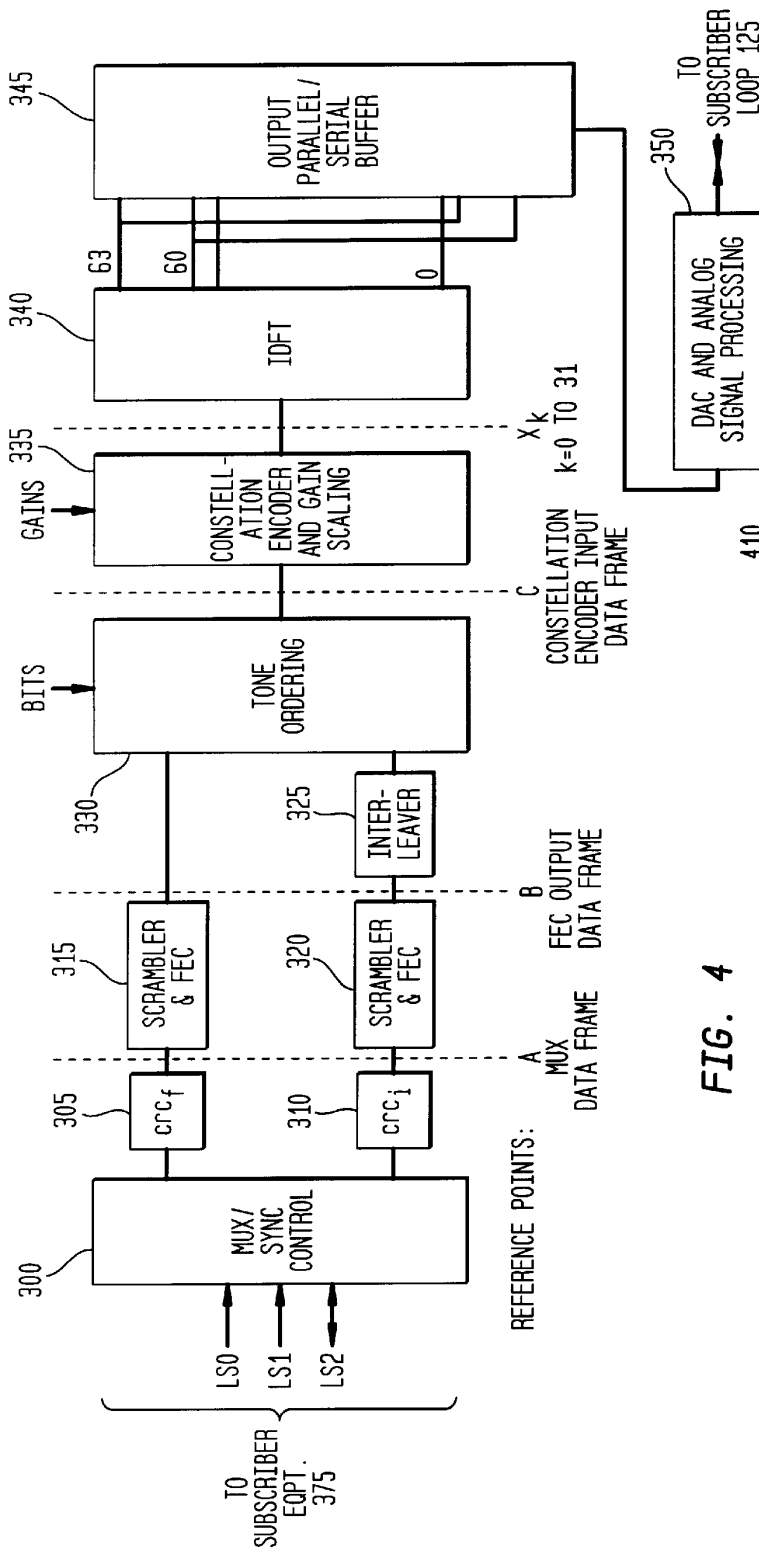
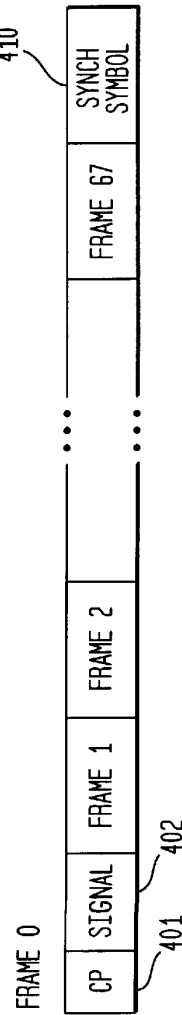


FIG. 4



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