United States Patent [19]

Frenkel

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[54] **APPARATUS AND METHODS FOR MODULATION AND DEMODULATION OF DATA**

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[51] **Int. Cl.**[6] **H03M 1/00**
[52] **U.S. Cl.** **341/11**
[58] **Field of Search** 341/111, 112, 341/114, 113, 115, 116; 332/103; 375/61, 67

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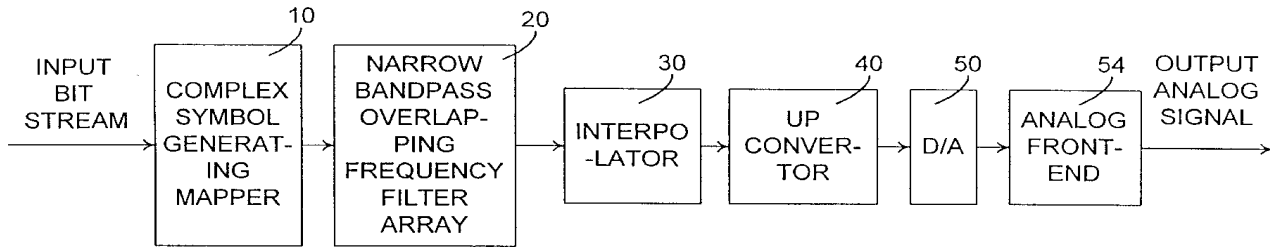*Primary Examiner*—Brian K. Young
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[57] **ABSTRACT**

A signal modulation method comprising receiving at least first and second synchronized incoming streams of complex symbols, thereby to define a plurality of incoming vectors each including at least first and second synchronized com-plex symbols, mapping each complex symbol into a signal component comprising a linear combination of an in-phase signal and a quadrature signal, the quadrature signal com-prising a Hilbert transform of said in-phase signal, wherein all of the signal components are substantially mutually orthogonal and wherein the frequency spectrums of all signal components mapped from a single incoming stream are centered around a common frequency location which is unique to the single incoming stream and wherein the frequency spectrums of signal components mapped from different incoming streams having adjacent common fre-quency locations are partially overlapping and wherein signal components mapped from sequential incoming sym-bols partially overlap in time and combining all of the signal components into a representation of an output signal.
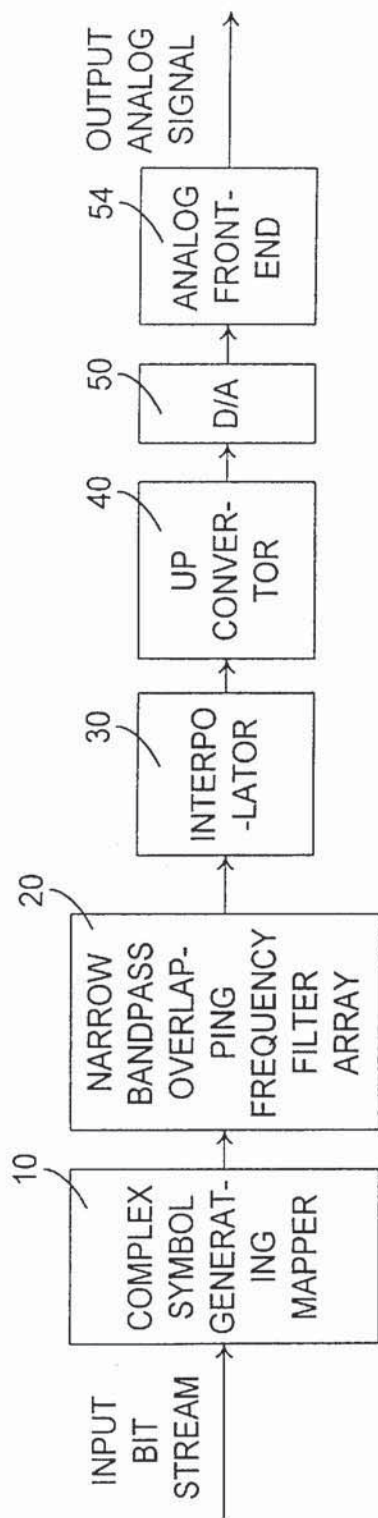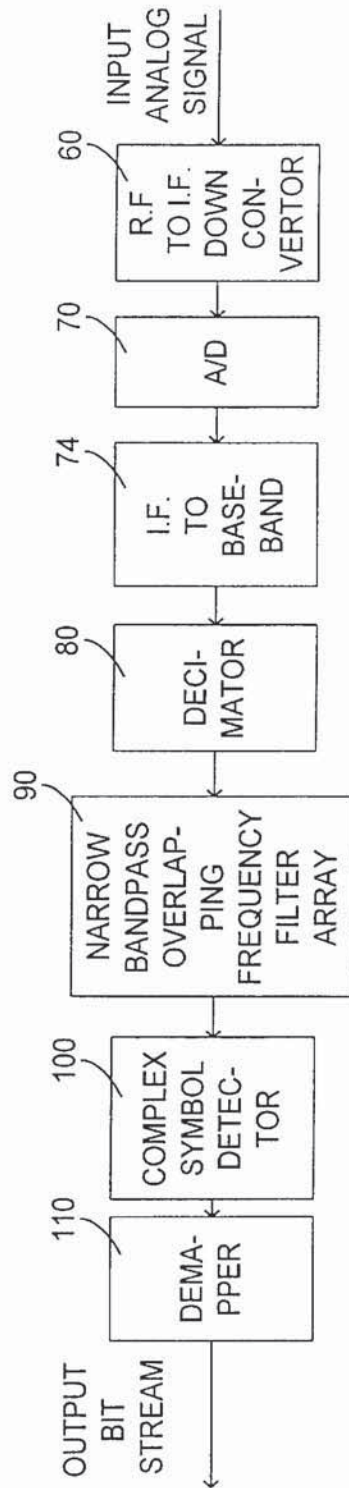
30 Claims, 15 Drawing Sheets

INPUT BIT STREAM

10 COMPLEX SYMBOL GENERAT-ING MAPPER

20 NARROW BANDPASS OVERLAP-PING FREQUENCY FILTER ARRAY

30 INTERPO-LATOR

40 UP CONVER-TOR

50 D/A

54 ANALOG FRONT-END

OUTPUT ANALOG SIGNAL

FIGURE 1

INPUT ANALOG SIGNAL

60 R.F TO I.F. DOWN CON-VERTOR

70 A/D

74 I.F. TO BASE-BAND

80 DECI-MATOR

90 NARROW BANDPASS OVERLAP-PING FREQUENCY FILTER ARRAY

100 COMPLEX SYMBOL DETEC-TOR

110 DEMA-PPER

OUTPUT BIT STREAM

FIGURE 2

FIGURE 3

200

$A_0(n)$ → ZERO PAD ↑M → 204 FILTER NUMBER 0 $g_0(i) = g(i)$

200

$A_1(n)$ → ZERO PAD ↑M → 204 FILTER NUMBER 1 $g_1(i) = g(i) \cdot \exp(j\frac{2\pi}{N} \cdot 1 \cdot i)$

200

$A_{N-1}(n)$ → ZERO PAD ↑M → 204 FILTER NUMBER N-1 $g_{N-1}(i) = g(i) \cdot \exp(j\frac{2\pi}{N} \cdot (N-1) \cdot i)$

208 SUM → D

FIGURE 4A

210

$A_0(n)$, $A_1(n)$, ..., $A_{N-1}(n)$ → IFFT → $C_0(n)$, $C_1(n)$, ..., $C_{N-1}(n)$

220 MULTIPLY AND ACCUMULATE MACHINE

$$D_k(n) = \sum_{i=0}^{L-1} g(k+iM) \cdot C_{(k+iM)\bmod N}(n-i)$$

$$\text{where } k = 0,1,2,...,M-1$$

$D_0(n)$, $D_1(n)$, ..., $D_{N-1}(n)$, ..., $D_{M-1}(n)$

230 CONCATENATOR → D

FIGURE 4B

DOCKET ALARM
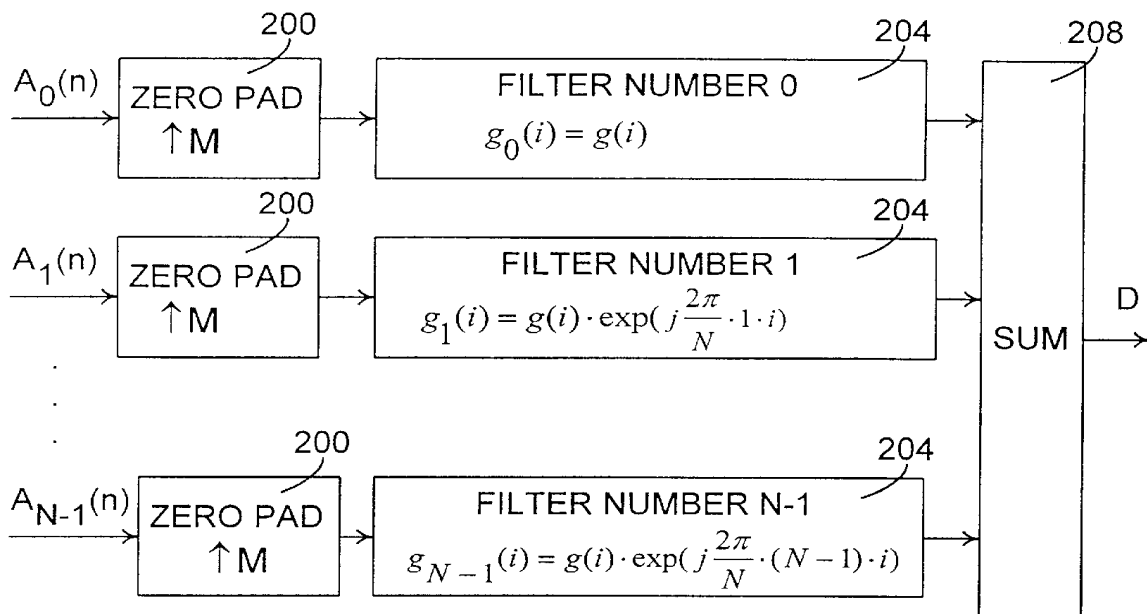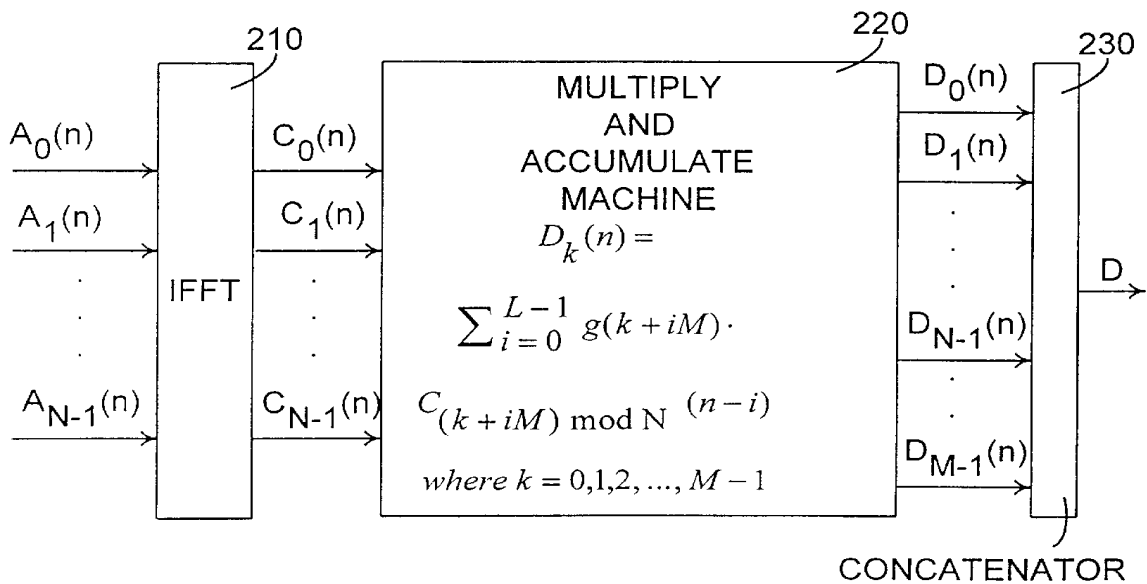
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