United States Patent [19]

Hughes-Hartogs

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[54] **ENSEMBLE MODEM STRUCTURE FOR IMPERFECT TRANSMISSION MEDIA**

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[73] Assignee: **Telebit Corporation,** Mountain View, Calif.

[21] Appl. No.: **140,848**

[22] Filed: **Jan. 5, 1988**

Related U.S. Application Data

[62] Division of Ser. No. 2,096, Jan. 12, 1987, Pat. No. 4,731,816, which is a division of Ser. No. 736,200, May 20, 1985, Pat. No. 4,679,227.

[51] **Int. Cl.^{4}** **H04M 11/00**
[52] **U.S. Cl.** **379/98;** 370/19; 375/39
[58] **Field of Search** 375/38, 39, 40, 58, 375/118; 455/63, 68; 340/825.15; 370/16, 19, 69.1, 70, 100, 106, 108; 379/93, 97, 98

[56] **References Cited**

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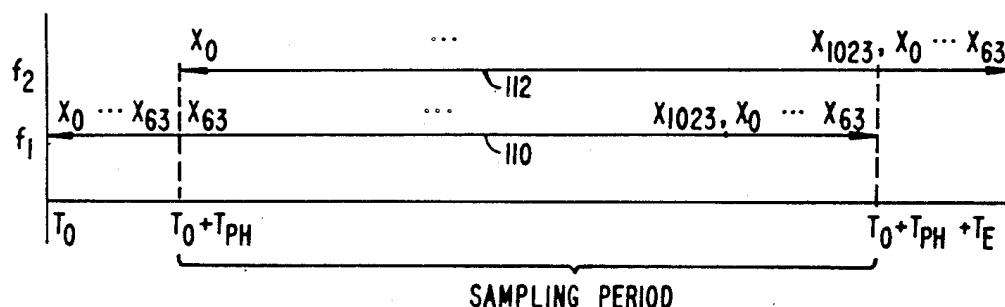|			
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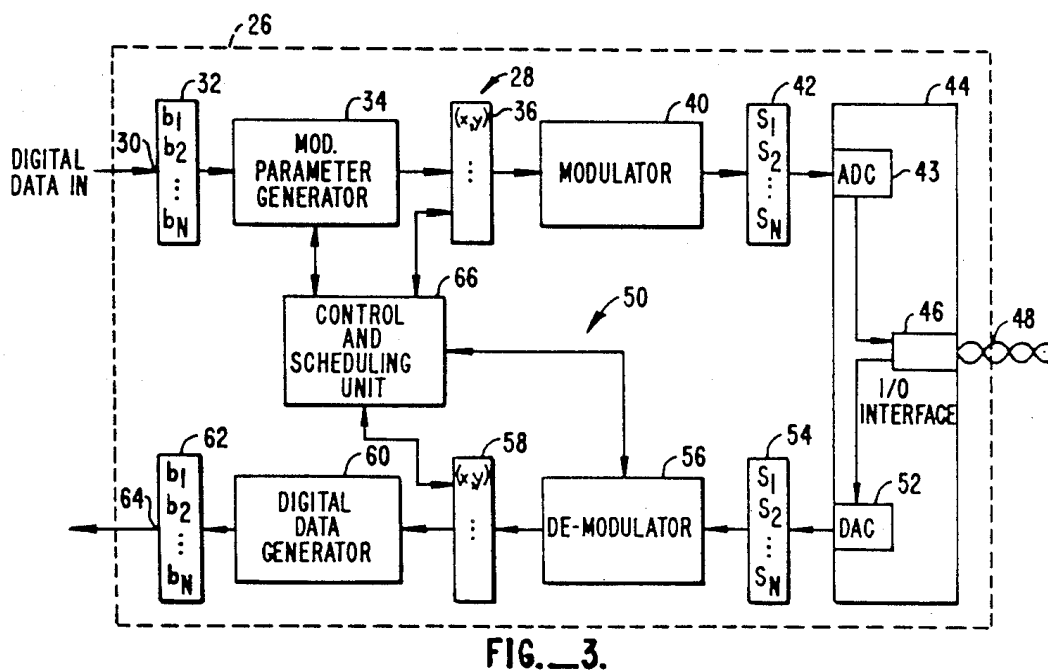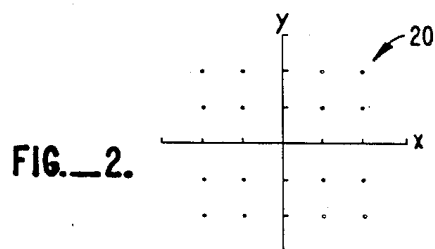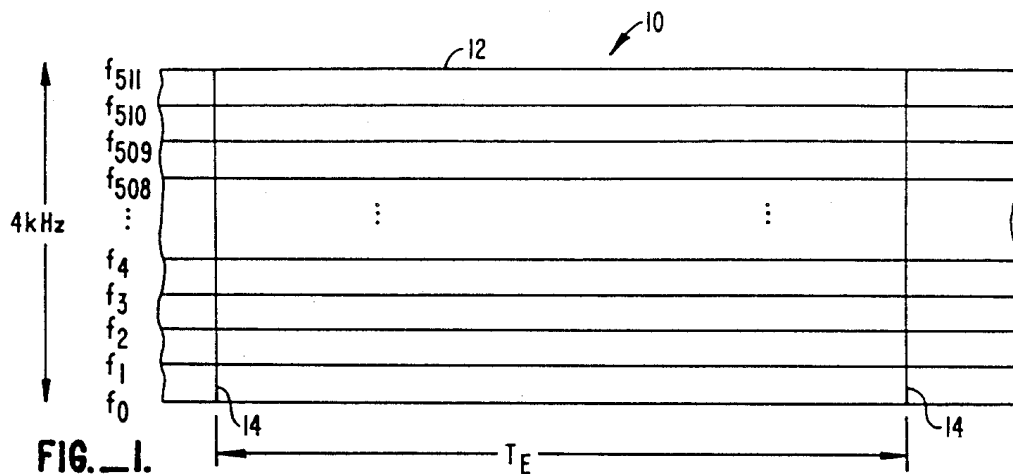
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Assistant Examiner—Randall S. Vaas
Attorney, Agent, or Firm—Townsend and Townsend

[57] **ABSTRACT**

A high-speed modem that transmits and receives digital data on an ensemble of carrier frequencies spanning the usable band of a dial-up telephone line. The modem includes a system for variably allocating data and power among the carriers to compensate for equivalent noise and to maximize the data rate. Additionally, systems for eliminating the need for an equalization network, for adaptively allocating control of a channel, and the tracking variations in line parameters are disclosed.
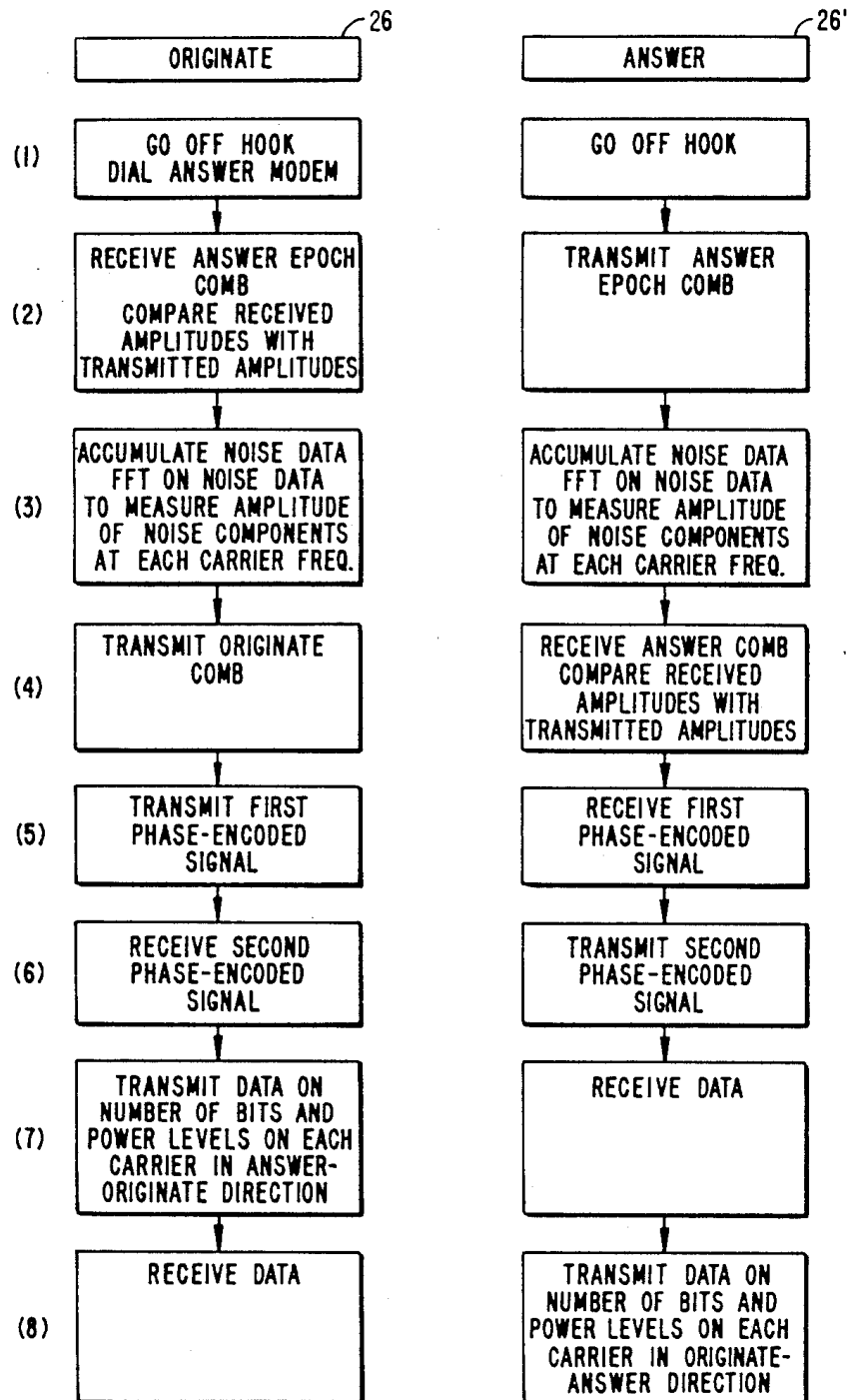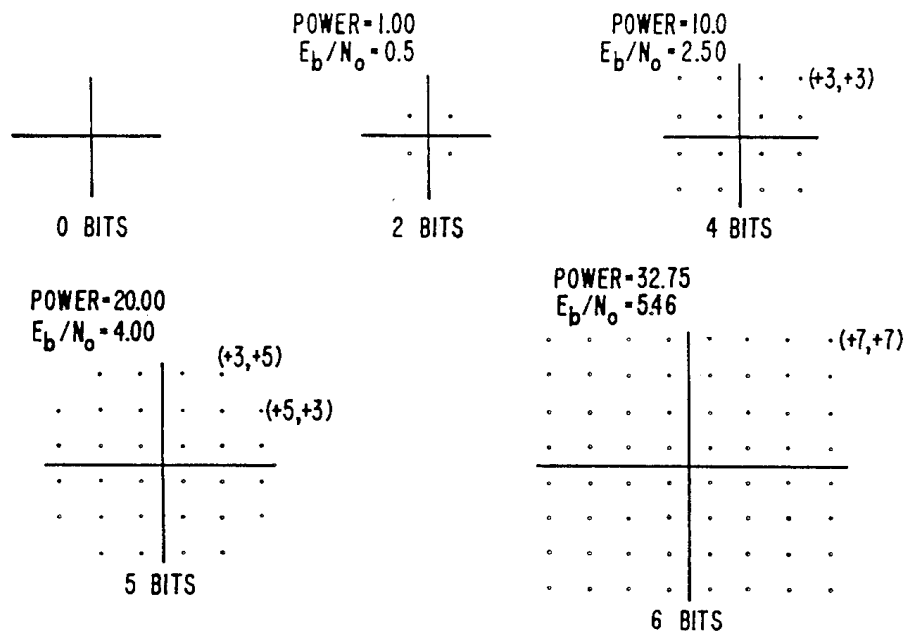
2 Claims, 6 Drawing Sheets

SAMPLING PERIOD
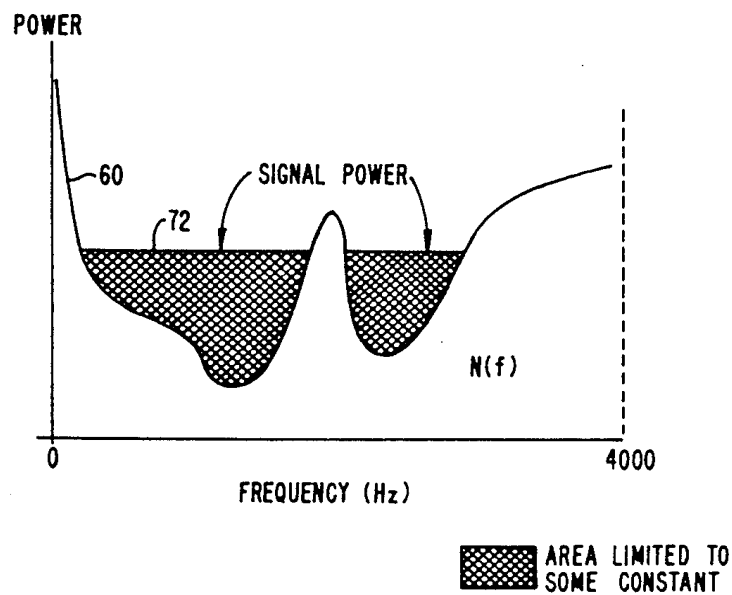
FIG.—1.

FIG.—2.

FIG.—3.

ORIGINATE ⌐26

ANSWER ⌐26'

(1)

GO OFF HOOK
DIAL ANSWER MODEM

GO OFF HOOK

(2)

RECEIVE ANSWER EPOCH
COMB
COMPARE RECEIVED
AMPLITUDES WITH
TRANSMITTED AMPLITUDES

TRANSMIT ANSWER
EPOCH COMB

(3)

ACCUMULATE NOISE DATA
FFT ON NOISE DATA
TO MEASURE AMPLITUDE
OF NOISE COMPONENTS
AT EACH CARRIER FREQ.

ACCUMULATE NOISE DATA
FFT ON NOISE DATA
TO MEASURE AMPLITUDE
OF NOISE COMPONENTS
AT EACH CARRIER FREQ.

(4)

TRANSMIT ORIGINATE
COMB

RECEIVE ANSWER COMB
COMPARE RECEIVED
AMPLITUDES WITH
TRANSMITTED AMPLITUDES

(5)

TRANSMIT FIRST
PHASE-ENCODED
SIGNAL

RECEIVE FIRST
PHASE-ENCODED
SIGNAL

(6)

RECEIVE SECOND
PHASE-ENCODED
SIGNAL

TRANSMIT SECOND
PHASE-ENCODED
SIGNAL

(7)

TRANSMIT DATA ON
NUMBER OF BITS AND
POWER LEVELS ON EACH
CARRIER IN ANSWER-
ORIGINATE DIRECTION

RECEIVE DATA

(8)

RECEIVE DATA

TRANSMIT DATA ON
NUMBER OF BITS AND
POWER LEVELS ON EACH
CARRIER IN ORIGINATE-
ANSWER DIRECTION

FIG.—4.

POWER=1.00
$E_b/N_o = 0.5$

0 BITS

POWER=10.0
$E_b/N_o = 2.50$

2 BITS

POWER=10.0
$E_b/N_o = 2.50$

·(+3,+3)

4 BITS

POWER=20.00
$E_b/N_o = 4.00$

(+3,+5)

·(+5,+3)

5 BITS

POWER=32.75
$E_b/N_o = 5.46$

·(+7,+7)

6 BITS

FIG._5.

POWER

60

72

SIGNAL POWER

N(f)

0   4000

FREQUENCY (Hz)

AREA LIMITED TO
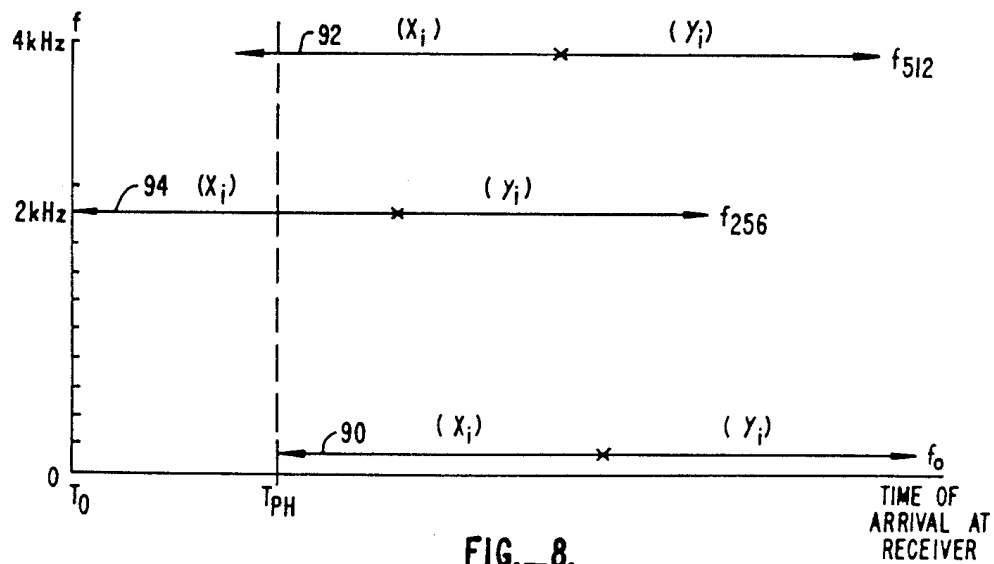SOME CONSTANT

FIG._6.

FIG.__7.

FIG.__8.

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