(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
8 January 2004 (08.01.2004)

PCT

(10) International Publication Number
WO 2004/004193 A2

(51) International Patent Classification[7]: H04L

(21) International Application Number: PCT/US2003/020862

(22) International Filing Date: 1 July 2003 (01.07.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/392,861 1 July 2002 (01.07.2002) US

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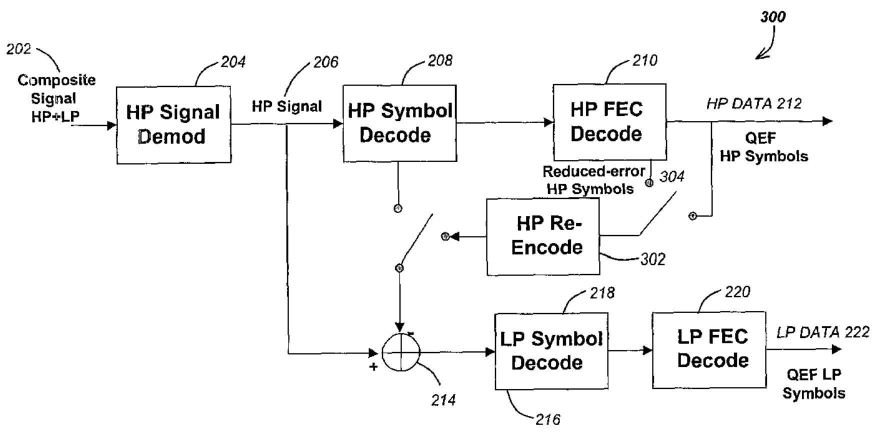
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv)) for US only*

[Continued on next page]

(54) Title: IMPROVING HIERARCHICAL 8PSK PERFORMANCE



(57) Abstract: A method and receiver systems for demodulating and decoding a hierarchically modulated signal, e.g. an 8PSK signal, are disclosed. An exemplary method includes demodulating and processing (502) the hierarchically modulated signal (202) to produce symbols (212) from the first modulation at the first hierarchical level, applying information (504) from a plurality of the symbols from the first modulation at the first hierarchical level in subtracting (214) from the demodulated hierarchically modulated signal to obtain the second modulation at the second hierarchical level and processing (506) the second modulation at the second hierarchical level to produce second symbols (222) from the demodulated second signal. The hierarchically modulated signal comprises a non-uniform 8PSK signal. Applying the information from the plurality of the symbols from the first modulation can be achieved by applying the symbols after error correction. A decision-directed demodulation of the first modulation can also be used to further improve performance.

WO 2004/004193 A2

Published:
— *without international search report and to be republished upon receipt of that report*

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IMPROVING HIERARCHICAL 8PSK PERFORMANCE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to the following U.S. Provisional Patent Application, which is incorporated by reference herein:

[0002] U.S. Provisional Patent Application Serial No. 60/392,861, filed on July 1, 2002, and entitled "IMPROVING HIERARCHICAL 8PSK PERFORMANCE", by Ernest C. Chen et al.

[0004] This application is related to U.S. Patent Application Serial No. 09/844,401, filed on April 27, 2001, and entitled "LAYERED MODULATION FOR DIGITAL SIGNALS", by Ernest C. Chen, which application is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention.

[0005] The present invention relates generally to systems for transmitting and receiving digital signals, and in particular, to systems for broadcasting and receiving digital signals using hierarchical modulation techniques.

2. Description of the Related Art.

[0006] Digital signal communication systems have been used in various fields, including digital TV signal transmission, either terrestrial or satellite.

[0007] As the various digital signal communication systems and services evolve, there is a burgeoning demand for increased data throughput and added services. However, it is more difficult to implement either improvement in old systems and new services when it is necessary to replace existing legacy hardware, such as transmitters and receivers. New systems and services are advantaged when they can utilize existing legacy hardware. In the realm of wireless communications, this principle is further highlighted by the limited availability of electromagnetic spectrum. Thus, it is not possible (or at least not practical) to merely transmit enhanced or additional data at a new frequency.

[0008] The conventional method of increasing spectral capacity is to move to a higher-order modulation, such as from quadrature phase shift keying (QPSK) to eight phase shift keying (8PSK) or sixteen quadrature amplitude modulation (16QAM). Unfortunately, QPSK receivers cannot demodulate conventional 8PSK or 16QAM signals. As a result, legacy customers with QPSK receivers must upgrade their receivers in order to continue to receive any signals transmitted with an 8PSK or 16QAM modulation.

[0009] Techniques have been identified for modifying the basic modulated QPSK signal to higher order modulation techniques (e.g. 8PSK) to allow additional data to be transmitted and received by upgraded or second generation receivers. These techniques are also backwards-compatible. That is, they allow legacy receivers to receive and process the same basic QPSK signal essentially as if the additional data was not present. One such technique is hierarchical modulation. Hierarchical modulation is a technique where the standard 8PSK constellation is modified to create a "non-uniform" 8PSK constellation that transmits two signals (1) a QPSK signal that can be configured so as to be backwards-compatible with existing receivers, and (2) a generally more power efficient, non-backwards compatible signal . The backwards-compatible QPSK signal can be used to transmit high priority (HP) data, while the non-backwards-compatible signal can be used to transmit low priority (LP) data. While the HP signal is constrained to be the legacy signal, the LP signal has more freedom and can be encoded more efficiently using an advanced forward error correction (FEC) coding scheme such as a turbo code.

[0010] The application of conventional hierarchical demodulation techniques can result in excessive symbol errors in the LP data signal. Such errors can occur because of the excessive tracking errors in the timing/carrier recovery loop used in demodulating HP data signal, and in excessive symbol errors from the demodulated HP data signal.

[0011] What is needed is a system and method for receiving hierarchically modulated symbols, such as in non-uniform 8PSK, that reduces LP data signal errors and provides for improved performance. The present invention satisfies that need.

SUMMARY OF THE INVENTION

[0012] To improve the demodulator performance, embodiments of the invention take advantage of the fact that quasi-error free (QEF) upper layer (UL) symbols are available from HP demodulation. These essentially error-free symbols may be used to completely cancel out the UL signal from the received signal for a cleaner lower layer (LL) signal. They may also be used in a second refining tracking loop to reduce the loop noise for further performance improvement. The result is improved LL signal quality and therefore better BER performance with this invention. The terminology UL and LL used in Layered modulation are synonymous to HP and LP used in hierarchical modulation, respectively.

[0013] Embodiments of the invention can reduce the signal to noise ratio (SNR) required for the non-uniform 8PSK technique, mentioned above, thereby reducing the required satellite amplifier output power. For example, in embodiments of the invention, the required satellite amplifier output power may be decreased for a given receiver antenna size, or the receiver antenna size may be reduced for a given satellite amplifier output power, etc..

[0014] A typical method of the invention comprises the steps of demodulating and processing a hierarchically modulated signal to produce symbols from a first modulation at a first hierarchical level, applying information from a plurality of the symbols from the first modulation at the first hierarchical level in subtracting from the demodulated hierarchically modulated signal to obtain a second modulation at a second hierarchical level and processing the second modulation at the second hierarchical level to produce second symbols from the demodulated second signal. The hierarchically modulated signal comprises a non-uniform 8PSK signal. The applied information from the plurality of symbols from the first modulation can be achieved through application of the symbols from the first modulation after error correction, e.g. forward error correction (FEC) or some other technique to improve the accuracy of the output symbols from the first modulation.

[0015] A typical receiver can include a first demodulator for demodulating the first modulation of the hierarchically modulated signal, a symbol decoder, communicatively coupled to the first demodulator, for producing symbols from the demodulated first signal, an error decoder, communicatively coupled to the symbol decoder, for producing an error corrected symbol stream from the symbols from the demodulated first signal, a re-encoder for re-encoding the error corrected symbol stream, a remodulator for remapping the error corrected symbol stream to a baseband signal, a subtractor, communicatively coupled to the remodulator and the first demodulator, for subtracting the remodulated symbol stream from the first signal to produce a second signal, and a second symbol decoder, communicatively coupled to the subtractor for producing second symbols from the demodulated second signal. If the hierarchically modulated signal is coherent, such as the hierarchical non-uniform 8PSK, a greatly reduced second level demodulator can be communicatively coupled between the subtractor and the second symbol decoder for demodulating the second signal from the subtractor and providing the demodulated second signal to the second symbol decoder.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Referring now to the drawings in which like reference numbers represent corresponding parts throughout:

[0017] FIG. 1A is a diagram illustrating a QPSK signal constellation;

[0018] FIG. 1B is a diagram illustrating a non-uniform 8PSK signal constellation achieved through hierarchical modulation;

[0019] FIG. 2 is a diagram illustrating a system for demodulating a hierarchical non-uniform 8PSK signal such as that which is illustrated in FIG. 1B;

[0020] FIG. 3 is a diagram illustrating a system for demodulating a hierarchical non-uniform 8PSK signal resulting in fewer errors than the system illustrated in FIG. 2;

[0021] FIG. 4 is a block diagram of another embodiment of a system for demodulating the hierarchical non-uniform 8PSK signal; and

[0022] FIG. 5 is a flowchart of an exemplary method of the invention for demodulating a hierarchical non-uniform 8PSK signal.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0023] In the following description, reference is made to the accompanying drawings which form a part hereof, and which show, by way of illustration, several embodiments of the present invention. It is understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the present invention.

HIERARCHICAL MODULATION/DEMODULATION

[0024] FIG. 1A is a diagram illustrating a signal constellation for a QPSK HP data signal. The signal constellation includes four possible signal outcomes 102 for A and B wherein {A,B} = {0,0} (point 102A in the first quadrant), {1,0} (point 102B in the second quadrant), {1,1} (point 102C in the third quadrant), and {0,1} (point 102D in the fourth quadrant). An incoming and demodulated signal mapped to one of quadrants (I-IV) and the value for {A,B} (and hence, the value for the relevant portion of the HP data stream) is determined therefrom.

[0025] FIG. 1B is a diagram illustrating an 8PSK constellation created by addition of an LP data stream (represented by "C"). The application of hierarchical modulation adds two possible data values for "C" (C = {1,0}) to each of the outcomes 102A-102D. For example, outcome 102A ({A,B} = {0,0}) is expanded to an outcome pair 104A and 104A' ({A,B,C} = {0,0,1} and {0,0,0}), respectively, with the members of the pair separated by an angle Θ from {A,B}. This expands the signal constellation to include 8 nodes 104A-104D (each shown as solid dots).

[0026] If the angle Θ is small enough, a legacy QPSK signal will receive both {A,B,C} = {0,0,1} and {0,0,0} as {A,B} = {0,0}. Only receivers capable of performing the second hierarchical level of modulation (LP) can extract the value for {C} as either {0} or {1}. This hierarchical signal structure has been termed "non-uniform" 8PSK.

[0027] The choice of the variable Θ depends on a variety of factors. FIG. 1B, for example, presents the idealized data points without noise. Noise and errors in the transmission and/or reception of the signal vary the actual position of the nodes 104A-104D and 104A'-104D' in FIG. 1B. Noise regions 106 surrounding each node indicate areas in the constellation where the measured data may actually reside. The ability of the receiver to detect the symbols and accurately represent them depends on the angle

Θ, the power of the signal (e.g. the carrier), represented by r_c, and the noise (which can be represented by r_n). As can be seen by inspecting FIG. 1B, interference of LP into HP is reduced as signal power increases, or as Θ decreases. The performance of this hierarchical modulating system can be expressed in terms of its carrier to interference ratio (C/I).

[0028] With a Layered-type demodulation as in this invention, the noise contributed by UL symbol errors to the extracted LL signal is avoided. With a Layered modulation mapping, the LP bit value for the 8 nodes alternates between 0 and 1 around the circle, i.e., {0,1,0,1,0,1,0,1}. This is in contrast with the {0,0,1,1,0,0,1,1} assignment in Figure 1B for the conventional hierarchical modulation. Layered demodulation first FEC-decodes the upper layer symbols with a quasi-error free (QEF) performance, then uses the QEF symbols to extract the lower layer signal. Therefore, no errors are introduced by uncoded lower layer symbol errors. The delay memory required to obtain the QEF upper layer symbols for this application presents a small additional receiver cost, particularly in consideration of the ever-decreasing solid state memory cost over time.

[0029] In a conventional hierarchical receiver using non-uniform 8PSK, the LP signal performance can be impacted by HP demodulator performance. The demodulator normally includes a timing and carrier recovery loop. In most conventional recovery loops, a decision-directed feedback loop is included. Uncoded symbol decisions are used in the prediction of the tracking error at each symbol time of the recovery loop. The tracking loop would pick up an error vector whenever a symbol decision is in error; the uncoded symbol error rate (SER) could be as high as 6% in many legacy systems An FEC-corrected demodulator of this invention avoids the degradation.

[0030] FIG. 2 is a diagram of an exemplary system for demodulating the hierarchically non-uniform 8PSK signal with Layer modulation, as described in FIG 1B, with the {0,1,0,1,0,1,0,1} LP bit assignment discussed above. The input signal 202 is provided to a first demodulator 204, which demodulates the incoming signal to produce the HP data signal. The demodulated HP data signal is then provided to a symbol decoder, which maps the demodulated signal value to a symbol. In the exemplary non-uniform 8PSK signal illustrated in FIG. 1B, this typically is implemented by determining which of the four constellation quadrants (I-IV) the demodulated data signal is located. The output symbols are then provided to a forward error correction (FEC) decoder 210, which corrects at least some of the potentially erroneous signals from the symbol decoder 208. Such erroneous signals can occur, for example, when additive noise or distortion of the data places the measurement close enough to an incorrect quadrant. This process is functionally analogous to that which is performed by legacy QPSK receivers tasked with decoding the QPSK signal shown in FIG. 1A.

[0031] The LP data signal 222 is obtained by the remaining elements illustrated in FIG. 2. A subtractor (or differencer) 214 computes the difference between the demodulated signal 206 and the HP data symbol 224 provided by the symbol decoder 208. This effectively removes the HP data signal, permitting the LP data signal to be demodulated by a second demodulator 216 and decoded by a second symbol decoder 218. The demodulated and decoded signal is then provided to a second FEC error decoder 220 to provide the LP data 222 signal. In the case of hierarchical non-uniform 8PSK signal, which is coherent between the HP and LP signals, demodulator 216 does not need to contain timing and carrier recovery functions of a complete demodulator.

[0032] Although the foregoing exemplary system 200 has been described with respect to separate (e.g. first and second) demodulators, symbol decoders, and error decoders, the system 200 can also be implemented by appropriate single functional elements performing the functions of multiple separate devices. Further, FIG. 2 represents an intuitive processing of hierarchical 8PSK. Alternately, a calculation of I-Q can be employed to improve performance.

[0033] In decoding a backwards-compatible hierarchically modulated signal, a two-step process is involved. In the first step, the "legacy" signal is processed. (The hierarchical signal is processed to obtain the HP data symbols with the LP signal component ignored as noise.) In the second step, the LP signal (e.g., new service signal) is processed. In a conventional method, symbol decisions are first made on the HP signal according to the quadrant in which the demodulated complex value resides. These "uncoded" symbol decisions could have a symbol error rate (SER) as high as 6%, operating at the CNR threshold. The LP signal is then extracted from the demodulated complex signal as a value relative to the uncoded symbol decisions. As a result, whenever an HP symbol decision is in error, the LP signal will pick up an error vector. Consequently, this error will degrade subsequent LP decoding performance in the form of an increased bit error rate (BER).

[0034] While the foregoing system 200 is capable of decoding both the HP data stream and the LP data stream, it does not make full use of the information that can be derived from the HP data stream to demodulate the LP data stream. The result is that the output LP data stream 222 is subject to some correctable errors.

[0035] FIG. 3 is a block diagram illustrating another system 300 for demodulating a hierarchically modulated signal. Unlike the system shown in FIG. 2, the system illustrated in FIG. 3 makes full use of the decoded HP data in demodulating the LP data. Unlike the system 200 illustrated in FIG. 2, the differencer 214 computes the difference between the demodulated signal 206 and a version of the HP symbol stream that has been re-encoded by a re-encoder 302. Unlike the system 200 depicted in FIG.

2, in which only one symbol at a time is used to remove the HP data signal from the demodulated signal 206, the system 300 shown in FIG. 3 uses information from a plurality of symbols to remove the HP data. This is accomplished by using an FEC decoded and re-encoded version of the HP symbol stream 304.

[0036] Also as previously mentioned, in the case of hierarchical non-uniform 8PSK signal, which is coherent between the HP and LP signals, demodulator 216 does not need to contain timing and carrier recovery functions of a complete demodulator. Accordingly, the second demodulator 216 and second symbol decoder 220 are shown as a single block in FIG. 3.

[0037] While the foregoing system 300 has been described using FEC, other coding and error reduction schemes may also be used to practice the present invention. All that is required is that the decoding and recoding implemented in the system 300 be compatible with the coding used in the input signal 202. Current work in hierarchical demodulation systems has not taught this application of error reduction in the HP data 212 to improve demodulation of the LP data 222.

[0038] FIG. 4 is a block diagram illustrating another embodiment of the present invention. This embodiment uses the demodulated and decoded HP data signal to improve performance characteristics of the demodulation of the input signal 202 that is used to recover the LP data signal. Here, the FEC decoded HP symbol stream 304 from the HP data 212 is provided to an FEC-corrected demodulator 402. The re-encoded signal permits the corrected-demodulator 402 to demodulate the input signal 202 with improved carrier/tracking recovery. This reduces errors and improves the BER of the LP data 222. As with the embodiment of FIG. 3, the embodiment of FIG. 4 also uses information from a plurality of symbols to remove the HP data because the HP symbols are applied after error correction.

[0039] Typical demodulators that can be employed for blocks 204, 216, and 402 are described in "Digital Communications, by Edward Lee and David G. Messerschmidt, 1994 on pp. 725-736 (carrier recovery) and pp. 737-764 (timing recovery), and "Digital Communication Receivers", by Heinrich Mayer et al., 1998 on pp. 79-88, both of which are hereby incorporated by reference herein.

[0040] In a separate FEC-corrected demodulator 402 shown in FIG. 4, the system 400 can be implemented by providing the FEC corrected and re-encoded HP symbol stream from the output of re-encoder 302 back to signal 406, this time without symbol decision errors. Further, FIGS. 2-4 illustrate embodiments that can receive and demodulate coherent and non-coherent HP and LP data signals. If the HP and LP signals are coherent, as in the case of hierarchical non-uniform 8PSK, the systems shown in FIGS. 2-4 can be simplified by greatly reducing or eliminating the LP signal demodulator 216. Accordingly, the second demodulator 216 and second symbol decoder 220 are shown as a single block in FIG. 4.

[0041] FIG. 5 is a flowchart of an exemplary method 500 of the invention for demodulating a hierarchical non-uniform 8PSK signal. The method 500 begins at step 502 by demodulating processing a hierarchically modulated signal to produce symbols from a first modulation at a first hierarchical level. At step 504, information is applied from a plurality of the symbols from the first modulation at the first hierarchical level in subtracting from the demodulated hierarchically modulated signal to obtain a second modulation at a second hierarchical level. Finally at step 506, the second modulation at the second hierarchical level is processed to produce second symbols from the demodulated second signal. The hierarchically modulated signal comprises a non-uniform 8PSK signal. The applied information from the plurality of symbols from the first modulation can be achieved through application of the symbols from the first modulation after error correction, e.g. forward error correction (FEC) or some other technique to improve the accuracy of the output symbols from the first modulation. The exemplary method 500 may be further modified consistent with the exemplary receivers of FIGS. 2-4. For example, the step 504 can be implemented by providing an FEC corrected and re-encoded HP symbol stream from the output of a re-encoder to demodulate the incoming signal, this time without symbol decision errors.

[0042] The foregoing description including the preferred embodiment of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is intended that the scope of the invention be limited not by this detailed description, but rather by the claims appended hereto. The above specification, examples and data provide a complete description of the manufacture and use of the invention. Since many embodiments of the invention can be made without departing from the scope of the invention, the invention resides in the claims hereinafter appended.

WHAT IS CLAIMED IS:

1. A method for demodulating and decoding a hierarchically modulated signal (202) having a first modulation at a first hierarchical level and a second modulation at a second hierarchical level, comprising the steps of:

demodulating and processing (502) the hierarchically modulated signal (202) to produce symbols (212) from the first modulation at the first hierarchical level;

applying information (504) from a plurality of the symbols from the first modulation at the first hierarchical level (212) in subtracting (214) from the demodulated hierarchically modulated signal to obtain the second modulation at the second hierarchical level; and

processing (506) the second modulation at the second hierarchical level to produce second symbols (222) from the demodulated second signal;

wherein the hierarchically modulated signal comprises a non-uniform 8PSK signal.

2. The method of claim 1, wherein applying information from the plurality of the symbols from the first modulation at the first hierarchical level comprises applying the symbols from the first modulation at the first hierarchical level after error correction (304).

3. The method of claim 2, wherein applying information from the plurality of the symbols includes performing an FEC-corrected demodulation (402) on the hierarchically modulated signal (202).

4. The method of claim 2, wherein the error correction comprises a forward error correction (FEC) process (210).

5. The method of claim 1, wherein processing the hierarchically modulated signal (202) to produce symbols from the first modulation at the first hierarchical level (212) includes a decision-directed carrier recovery process.

6. The method of claim 1, wherein the plurality of the symbols from the first modulation at the first hierarchical level (304) are re-encoded (302) before being subtracted (214) from the demodulated hierarchically modulated signal (206, 404).

7. The method of claim 1, wherein the hierarchically modulated signal (202) is coherent and processing the second modulation at the second hierarchical level to produce second symbols (222) includes decoding (218) the second modulated signal.

8. The method of claim 7, wherein the hierarchically modulated signal (202) is non-coherent and processing the second modulation at the second hierarchical level to produce second symbols (222) further includes demodulating (216) the second modulated signal.

9. A receiver system for performing any of the methods of claims 1 - 8, comprising:

a first demodulator (204) for demodulating the first modulation of the hierarchically modulated signal (202);

a symbol decoder (208), communicatively coupled to the first demodulator, for producing symbols from the demodulated first signal;

an error decoder (210), communicatively coupled to the symbol decoder (208), for producing an error corrected symbol stream (304) from the symbols from the demodulated first signal;

a re-encoder (302) for re-encoding the error corrected symbol stream (304);

a subtractor (214), communicatively coupled to the re-encoder (302) and the first demodulator (204), for subtracting the re-encoded symbol stream from the first signal to produce a second signal; and

a second symbol decoder (218), communicatively coupled to the subtractor (214) for producing second symbols from the second signal.

10. The receiver system of claim 9, further comprising a second level demodulator (216), communicatively coupled between the subtractor (214) and the second symbol decoder (218) for demodulating the second signal from the subtractor (214) and providing the demodulated second signal to the second symbol decoder (218);

wherein the hierarchically modulated signal is non-coherent.

11. The receiver system of claim 9, wherein the hierarchically modulated signal (202) is coherent.

12. The receiver system of claim 9, wherein the error decoder (210) comprises a forward error correction (FEC) decoder.

13. A receiver system for performing any of the methods of claims 1 - 8, comprising:

a first demodulator (204) for demodulating the first modulation of the hierarchically modulated signal;

a symbol decoder (208), communicatively coupled to the first demodulator, for producing symbols from the demodulated first signal;

an error decoder (210), communicatively coupled to the symbol decoder (208), for producing an error corrected symbol stream (304) from the symbols from the demodulated first signal;

a re-encoder (302) for re-encoding the error corrected symbol stream (304);

an error correcting demodulator (402), communicatively coupled to the re-encoder (302) for demodulating the hierarchical signal (202) using the error corrected and re-encoded symbols from the demodulated first signal.

a subtractor (214), communicatively coupled to the re-encoder (302) and the an error correcting demodulator (402), for subtracting the re-encoded symbol stream (404) from the error correcting demodulated hierarchical signal to produce a second signal; and

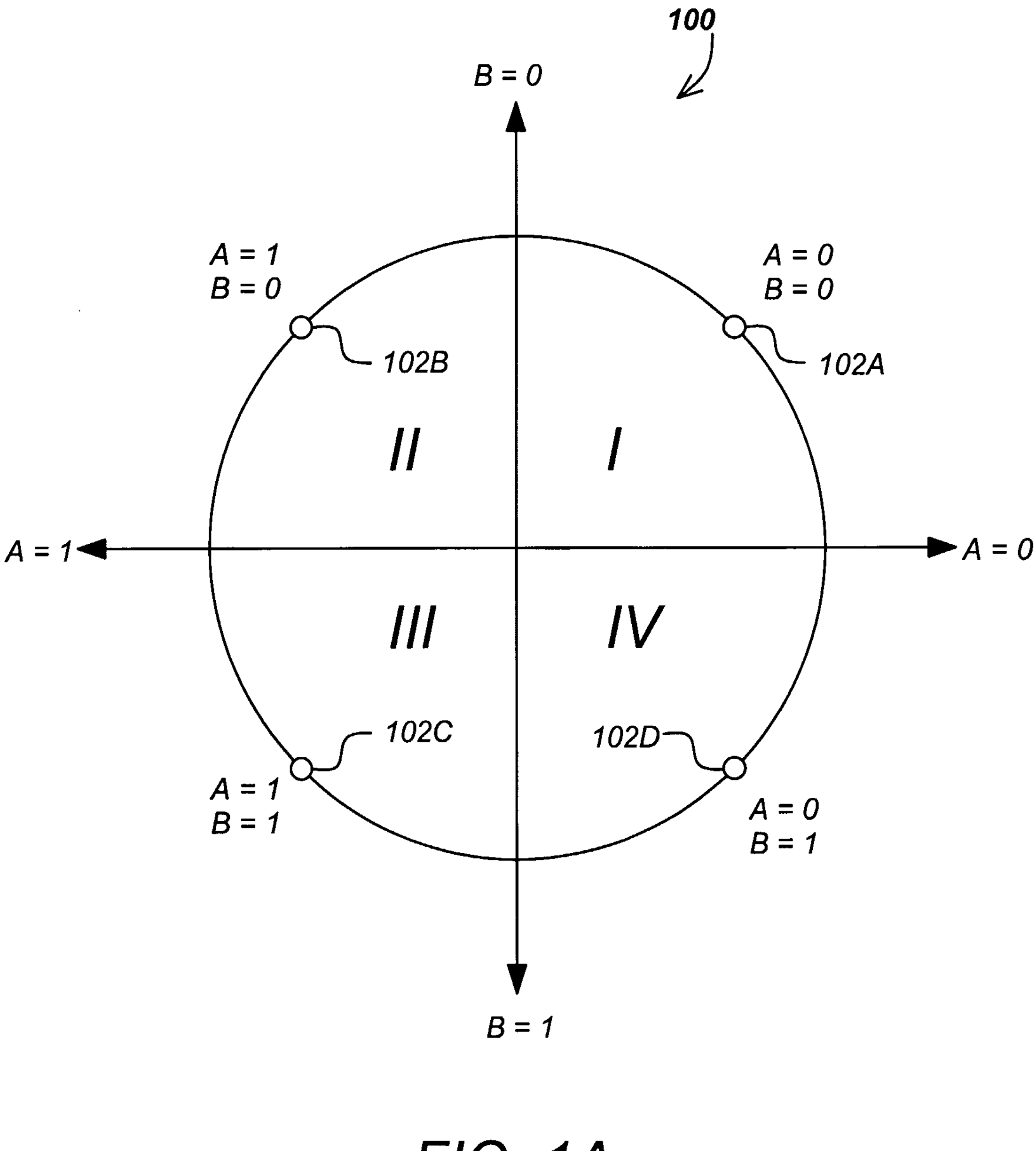
a second symbol decoder (218), communicatively coupled to the subtractor (214) for producing second symbols from the second signal.

14. The receiver system of claim 13, further comprising a second level demodulator (216), communicatively coupled between the subtractor (214) and the second symbol decoder (218) for demodulating the second signal from the subtractor (214) and providing the demodulated second signal to the second symbol decoder (218);

wherein the hierarchically modulated signal is non-coherent.

15. The receiver system of claim 13, wherein the hierarchically modulated signal (202) is coherent.

16. The receiver system of claim 13, wherein the error decoder (210) comprises a forward error correction (FEC) decoder.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B = 0
102B
102A
II
I
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III
IV
102C
102D
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B = 1
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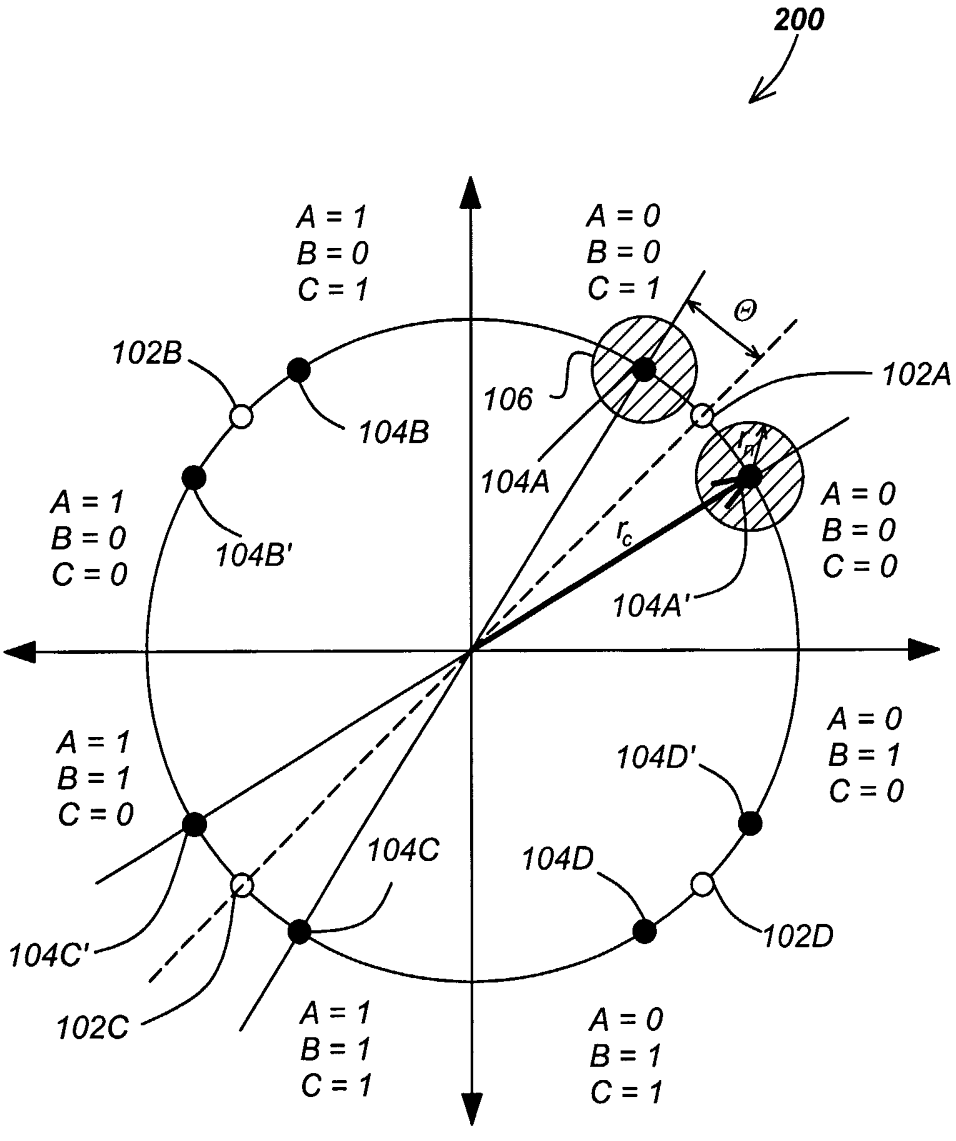
B = 1

FIG. 1A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B = 0
C = 1
Θ
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104B
106
102A
104A
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C = 0
104B'
A = 0
B = 0
C = 0
104A'
A = 1
B = 1
C = 0
104D'
A = 0
B = 1
C = 0
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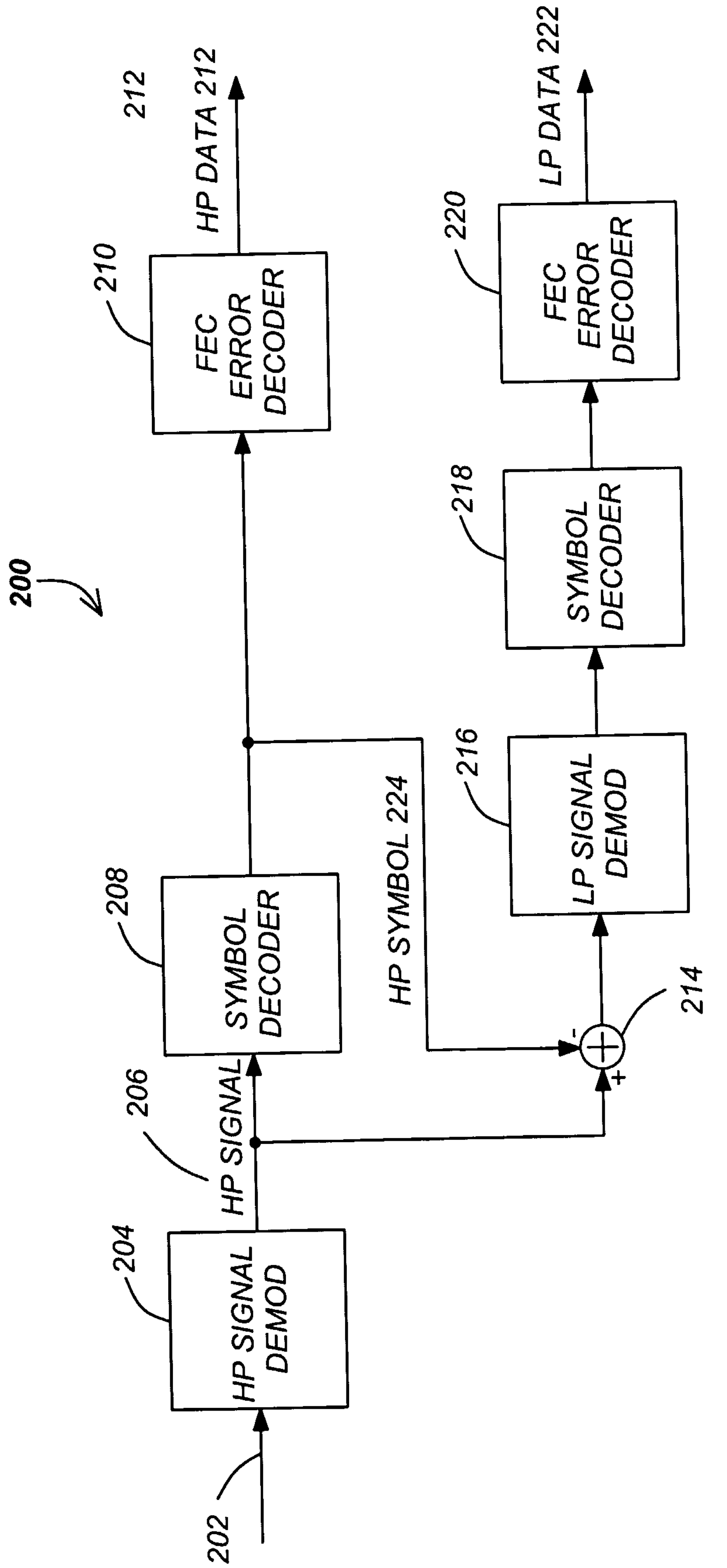
C = 1

FIG. 1B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202
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204
HP SIGNAL
206
SYMBOL DECODER
208
FEC ERROR DECODER
210
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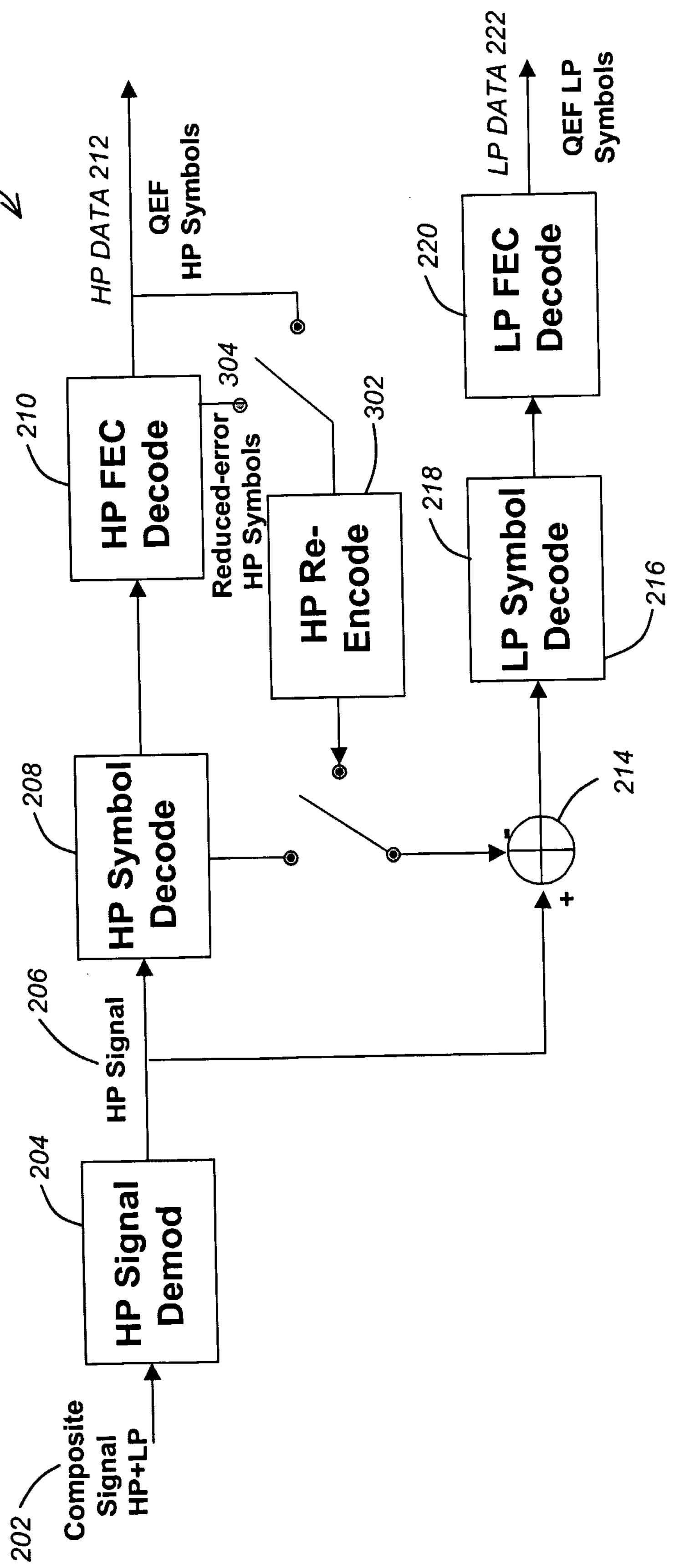
212
HP SYMBOL 224
214
LP SIGNAL DEMOD
216
SYMBOL DECODER
218
FEC ERROR DECODER
220
LP DATA 222

FIG. 2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202
Composite Signal HP+LP
204
HP Signal Demod
206
HP Signal
208
HP Symbol Decode
210
HP FEC Decode
HP DATA 212
QEF HP Symbols
304
Reduced-error HP Symbols
302
HP Re-Encode
214
218
LP Symbol Decode
216
220
LP FEC Decode
LP DATA 222
QEF LP Symbols

FIG. 3

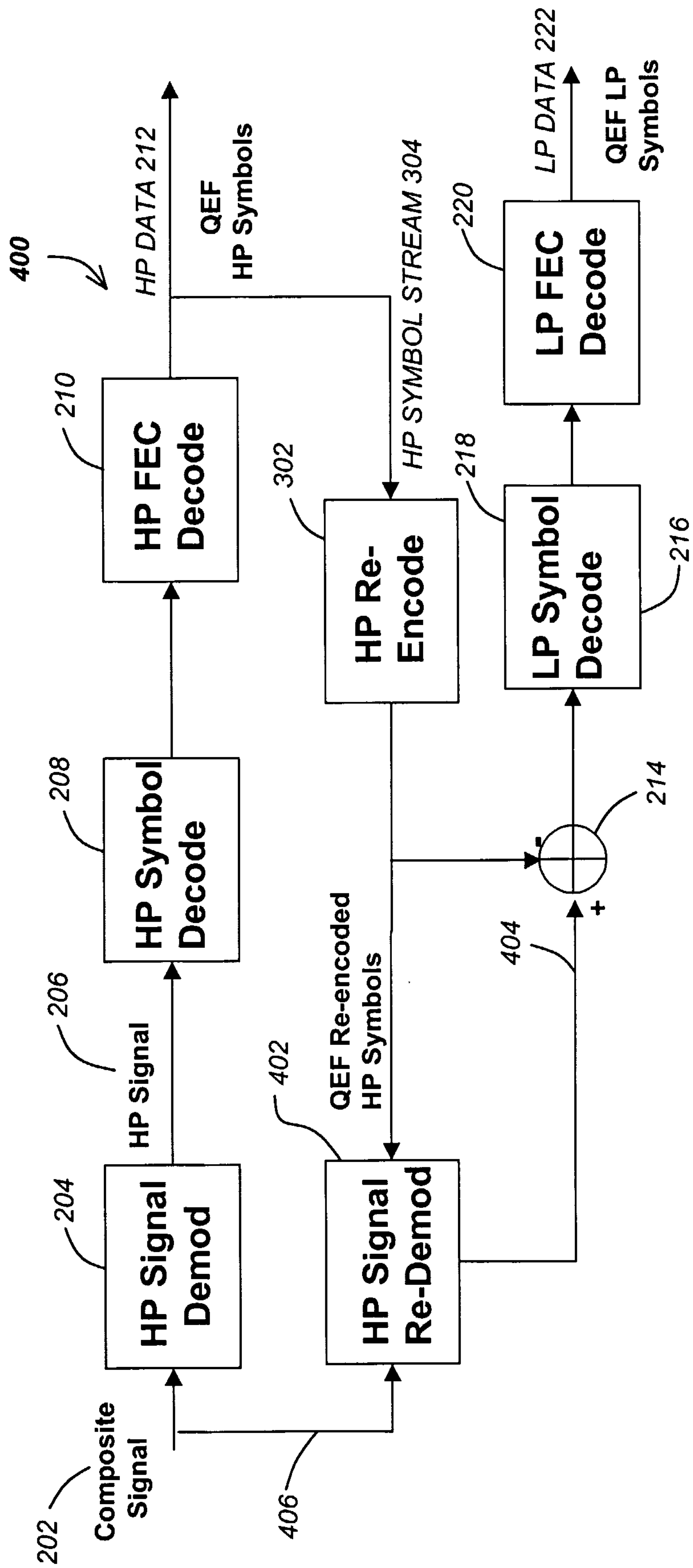
400
HP DATA 212
QEF
HP Symbols
HP SYMBOL STREAM 304
LP DATA 222
QEF LP
Symbols
210
HP FEC
Decode
220
LP FEC
Decode
302
HP Re-
Encode
218
LP Symbol
Decode
216
208
HP Symbol
Decode
214
206
HP Signal
404
402
QEF Re-encoded
HP Symbols
204
HP Signal
Demod
HP Signal
Re-Demod
202
Composite
Signal
406

FIG. 4

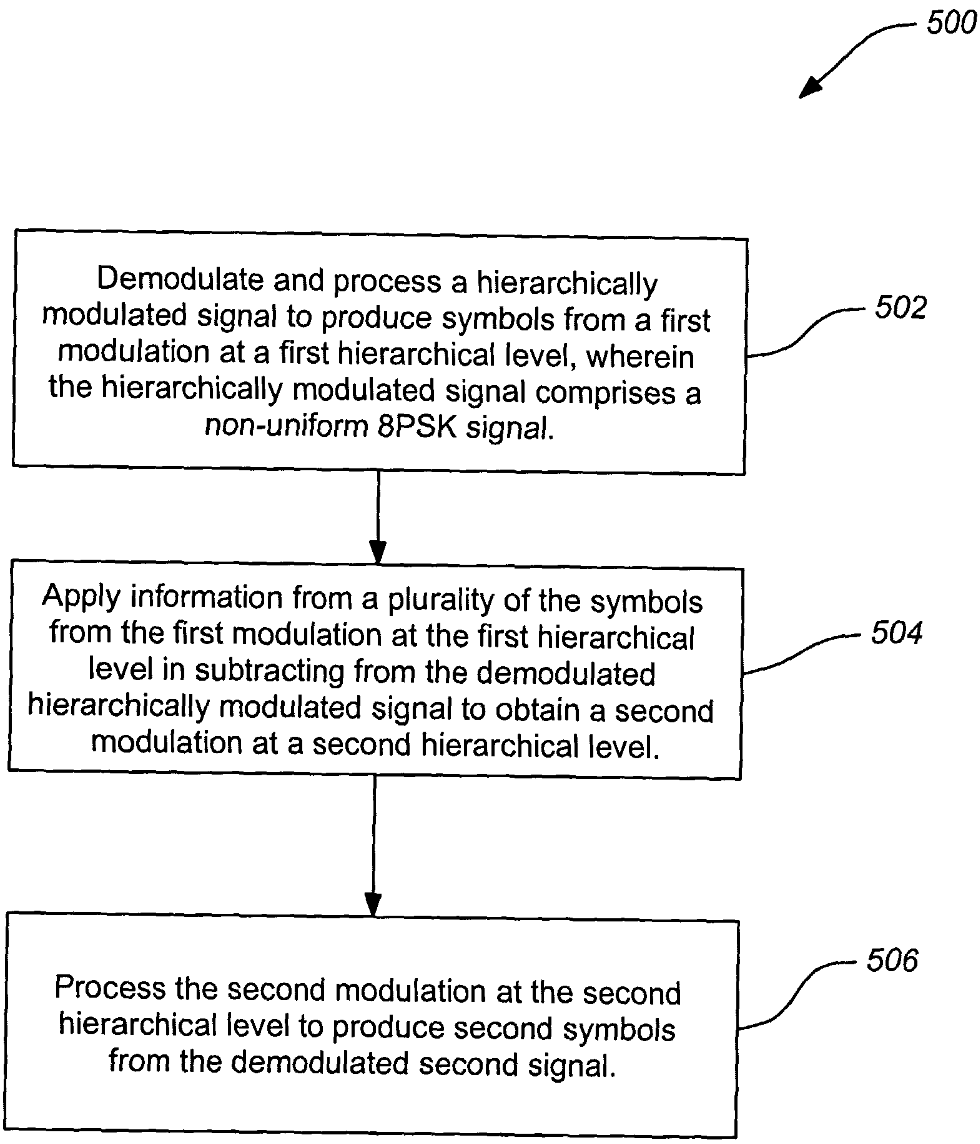
500
Demodulate and process a hierarchically modulated signal to produce symbols from a first modulation at a first hierarchical level, wherein the hierarchically modulated signal comprises a *non-uniform* 8PSK signal.
502
Apply information from a plurality of the symbols from the first modulation at the first hierarchical level in subtracting from the demodulated hierarchically modulated signal to obtain a second modulation at a second hierarchical level.
504
Process the second modulation at the second hierarchical level to produce second symbols from the demodulated second signal.
506

FIG. 5