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(54) **Method and apparatus for encoding long and short block length low density parity check (LDPC) codes**

Verfahren und Vorrichtung für die Encodierung von Low Density Parity Check (LDPC) Codes langer und kurzer Blocklänge

Méthod et appareil pour le codage de codes LDPC à longue et courte longueur de bloc

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to communication systems, and more particularly to coded systems.

BACKGROUND OF THE INVENTION

[0002] Communication systems employ coding to ensure reliable communication across noisy communication channels. For example, in a wireless (or radio) system, such as a satellite network, noise sources abound, from geographic and environmental factors. These communication channels exhibit a fixed capacity that can be expressed in terms of bits per symbol at certain signal to noise ratio (SNR), defining a theoretical upper limit (known as the Shannon limit). As a result, coding design has aimed to achieve rates approaching this Shannon limit. This objective is particularly germane to bandwidth constrained satellite systems. One such class of codes that approach the Shannon limit is Low Density Parity Check (LDPC) codes.

[0003] Traditionally, LDPC codes have not been widely deployed because of a number of drawbacks. One drawback is that the LDPC encoding technique is highly complex. Encoding an LDPC code using its generator matrix would require storing a very large, non-sparse matrix. Additionally, LDPC codes require large blocks to be effective; consequently, even though parity check matrices of LDPC codes are sparse, storing these matrices is problematic.

[0004] From an implementation perspective, a number of challenges are confronted. For example, storage is an important reason why LDPC codes have not become widespread in practice. Length LDPC codes, thus, require greater storage space. Also, a key challenge in LDPC code implementation has been how to achieve the connection network between several processing engines (nodes) in the decoder. Further, the computational load in the decoding process, specifically the check node operations, poses a problem.

[0005] Yu Y. et al.: "Design of semi-algebraic low density parity-check (SA-LDPC) codes for multilevel coded modulation" describes multilevel coded modulation using semi-algebraic LDPC codes.

[0006] There is a need for an LDPC communication system that employs simple encoding and decoding processes. There is also a need for using LDPC codes efficiently to support high data rates, without introducing greater complexity. There is also a need to improve performance of LDPC encoders and decoders. There is also a need to minimize storage requirements for implementing LDPC coding.

SUMMARY OF THE INVENTION

[0007] These and other needs are addressed by the present invention, wherein an approach for encoding Low Density Parity Check (LDPC) codes is provided. An encoder generates a LDPC code having an outer Bose Chaudhuri Hocquenghem (BCH) code according to one of Tables 1-6 for transmission as the LDPC coded signal. Each of the Tables 1-6 specifies the address of parity bit accumulators. The approach advantageously provides expedient encoding as well as decoding of LDPC codes, while minimizing storage and processing resources.

[0008] According to another aspect of an embodiment of the present invention, the LDPC codes are represented by signals that are modulated according to a signal constellation that includes one of 8-PSK (Phase Shift Keying), 16-QAM (Quadrature Amplitude Modulation), QPSK (Quadrature Phase Shift Keying), 16-APSK (Amplitude Phase Shift Keying) and 32-APSK.

[0009] According to yet another aspect of an embodiment of the present invention, the modulated LDPC coded signal is transmitted over a satellite link in support of a broadband satellite application.

[0010] Still other aspects, features, and advantages of the present invention are readily apparent from the following detailed description, simply by illustrating a number of particular embodiments and implementations, including the best mode contemplated for carrying out the present invention. The present invention is also capable of other and different embodiments, and its several details can be modified in various obvious respects, all without departing from the spirit and scope of the present invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

FIG. 1 is a diagram of a communications system configured to utilize Low Density Parity Check (LDPC) codes, according to an embodiment of the present invention;

FIGs. 2A and 2B are diagrams of exemplary LDPC encoders deployed in the transmitter of FIG. 1;

FIGs. 2C and 2D are flowcharts of the encoding process of the LDPC encoder of FIG. 2B for generating, respectively, long frame length codes and short frame length LDPC codes, according to an embodiment of the present invention;

FIG. 3 is a diagram of an exemplary receiver in the system of FIG. 1;

FIG. 4 is a diagram of a sparse parity check matrix, in accordance with an embodiment of the present invention;

FIG. 5 is a diagram of a bipartite graph of an LDPC code of the matrix of FIG. 4;

FIG. 6 is a diagram of a sub-matrix of a sparse parity check matrix, wherein the sub-matrix contains parity check values restricted to the lower triangular region, according to an embodiment of the present invention;

FIG. 7 is a graph of performance of the LDPC codes at rates 1/3 and 1/4 versus repetition codes;

FIG. 8 is a graph of performance of the LDPC codes at the various code rates and modulation schemes supported by the transmitter of FIG. 2A;

FIG. 9 is a diagram of a computing system that can perform the LDPC encoding process, in accordance with embodiments of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0012] A system, method, and software for efficiently encoding short frame length Low Density Parity Check (LDPC) codes are described. In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It is apparent, however, to one skilled in the art that the present invention may be practiced without these specific details or with an equivalent arrangement. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring the present invention.

[0013] FIG. 1 is a diagram of a communications system configured to utilize Low Density Parity Check (LDPC) codes, according to an embodiment of the present invention. A digital communications system 100 includes a transmitter 101 that generates signal waveforms across a communication channel 103 to a receiver 105. In this discrete communications system 100, the transmitter 101 has a message source that produces a discrete set of possible messages; each of the possible messages has a corresponding signal waveform. These signal waveforms are attenuated, or otherwise altered, by communications channel 103. To combat the noise in the channel 103, LDPC codes are utilized.

[0014] By way of example, the channel 103 is a satellite link serving satellite terminals (e.g., Very Small Aperture Terminals (VSATs)) in support of broadband satellite applications. Such applications include satellite broadcasting and interactive services (and compliant with the Digital Video Broadcast (DVB) - S2 standard). The Digital Video Broadcasting via Satellite (DVB-S) standard has been widely adopted worldwide to provide, for instance, digital satellite television programming.

[0015] The LDPC codes that are generated by the transmitter 101 enable high speed implementation without incurring any performance loss. These structured LDPC codes output from the transmitter 101 avoid assignment of a small number of check nodes to the bit nodes already vulnerable to channel errors by virtue of the modulation scheme (e.g., 8-PSK).

[0016] Such LDPC codes have a parallelizable decoding algorithm (unlike turbo codes), which advantageously involves simple operations such as addition, comparison and table look-up. Moreover, carefully designed LDPC codes do not exhibit any sign of error floor.

[0017] According to one embodiment of the present invention, the transmitter 101 generates, using a relatively simple encoding technique, LDPC codes based on parity check matrices (which facilitate efficient memory access during decoding) to communicate with the receiver 105. The transmitter 101 employs LDPC codes that can outperform concatenated turbo+RS (Reed-Solomon) codes, provided the block length is sufficiently large.

[0018] FIGs. 2A and 2B are diagrams of exemplary LDPC encoders deployed in the transmitter of FIG. 1. As seen in FIG. 2A, a transmitter 200 is equipped with an LDPC encoder 203 that accepts input from an information source 201 and outputs coded stream of higher redundancy suitable for error correction processing at the receiver 105. The information source 201 generates k signals from a discrete alphabet, X . LDPC codes are specified with parity check matrices. On the other hand, encoding LDPC codes require, in general, specifying the generator matrices. Even though it is possible to obtain generator matrices from parity check matrices using Gaussian elimination, the resulting matrix is no longer sparse and storing a large generator matrix can be complex.

[0019] The encoder 203 generates signals from alphabet Y to a modulator 205 using a simple encoding technique that makes use of only the parity check matrix by imposing structure onto the parity check matrix. Specifically, a restriction is placed on the parity check matrix by constraining certain portion of the matrix to be triangular. The construction of such a parity check matrix is described more fully below in FIG. 6. Such a restriction results in negligible performance loss, and therefore, constitutes an attractive trade-off.

[0020] The modulator 205 maps the encoded messages from encoder 203 to signal waveforms that are transmitted to a transmit antenna 207, which emits these waveforms over the communication channel 103. Accordingly, the encoded messages are modulated and distributed to a transmit antenna 207. The transmissions from the transmit antenna 207 propagate to a receiver (shown in FIG. 3), as discussed below.

[0021] FIG. 2B shows an LDPC encoder utilized with a Bose Chaudhuri Hocquenghem (BCH) encoder and a cyclic redundancy check (CRC) encoder, according to one embodiment of the present invention. Under this scenario, the codes generated by the LDPC encoder 203, along with the CRC encoder 209 and the BCH encoder 211, have a concatenated outer BCH code and an inner low density parity check (LDPC) code. Furthermore, error detection is achieved using cyclic redundancy check (CRC) codes. The CRC encoder 209, in an exemplary embodiment, encodes using an 8-bit CRC code with generator polynomial $(x^5+x^4+x^3+x^2+1)(x^2+x+1)(x+1)$. The CRC code is output to the BCH encoder 211.

[0022] FIG. 2C is a flowchart of the encoding process of the LDPC encoder of FIG. 2B for generating long frame length LDPC codes, according to an embodiment of the present invention. In step 221, information bits are received and processed to the chain of encoders 209, 211, and 203. Consequently, the LDPC encoder 203 generates LDPC codes with outer BCH codes based on the received information bits, as in step 223. The codes also contain the CRC code. Next, the LDPC codes are represented by signals that are modulated, per step 225, for transmission over the channel 103, which in an exemplary embodiment, is a satellite link to one or more satellite terminals (step 227).

[0023] The LDPC encoder 203 systematically encodes an information block of size k_{ldpc} , $i = (i_0, i_1, \dots, i_{k_{ldpc}-1})$ onto a codeword of size n_{ldpc} , $c = (i_0, i_1, \dots, i_{k_{ldpc}-1}, p_0, p_1, \dots, p_{n_{ldpc}-k_{ldpc}-1})$. The transmission of the codeword starts in the given order from i_0 and ends with $p_{n_{ldpc}-k_{ldpc}-1}$ LDPC code parameters (n_{ldpc}, k_{ldpc}) .

[0024] The task of the LDPC encoder 203 is to determine $n_{ldpc} - k_{ldpc}$ parity bits $(p_0, p_1, \dots, p_{n_{ldpc}-k_{ldpc}-1})$ for every block of k_{ldpc} information bits, $(i_0, i_1, \dots, i_{k_{ldpc}-1})$. The procedure is as follows. First, the parity bits are initialized;

$p_0 = p_1 = p_2 = \dots = p_{n_{ldpc}-k_{ldpc}-1} = 0$. By way of example, k_{ldpc} bits are systematically encoded to generate n_{ldpc} bits. The first information bit, i_0 , are accumulated at parity bit addresses specified in the first row of Tables 1-3. For the 1/3 rate code of Table 1, the relevant parameters are as follows: $q = 120$, $n_{ldpc} = 64800$, $k_{ldpc} = n_{BCH} = 21600$, $k_{BCH} = 21408$ (12 bit error correcting BCH). For the 1/4 rate, the LDPC code has the following relevant parameters: $q = 135$, $n_{ldpc} = 64800$, $k_{ldpc} = n_{BCH} = 16200$, $k_{BCH} = 16008$ (12 bit error correcting BCH). For long 2/5 LDPC code, the following parameters exist: $q = 108$, $n_{ldpc} = 64800$, $k_{ldpc} = n_{BCH} = 25920$, $k_{BCH} = 25728$ (12 bit error correcting BCH).

[0025] For example, for rate 1/3 (Table 1), the following results for i_0 :

$$p_{34903} = p_{34903} \oplus i_0$$

$$p_{20927} = p_{20927} \oplus i_0$$

$$p_{32093} = p_{32093} \oplus i_0$$

$$p_{1052} = p_{1052} \oplus i_0$$

$$p_{25611} = p_{25611} \oplus i_0$$

$$p_{16093} = p_{16093} \oplus i_0$$

$$p_{16454} = p_{16454} \oplus i_0$$

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$$p_{5520} = p_{5520} \oplus i_0$$

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$$p_{506} = p_{506} \oplus i_0$$

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$$p_{37399} = p_{37399} \oplus i_0$$

$$p_{18518} = p_{18518} \oplus i_0$$

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$$p_{21120} = p_{21120} \oplus i_0$$

In the above equations, the additions are in GF(2)).

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[0026] Then, for the next 359 information bits, $i_m, m = 1, 2, \dots, 359$, these bits are accumulated at parity bit addresses $\{x + m \bmod 360 \times q\} \bmod (n_{ldpc} - k_{ldpc})$, where x denotes the address of the parity bit accumulator corresponding to the first bit i_0 , and q is a code rate dependent constant. Continuing with the example with $q = 120$ for rate 1/3, for information bit i_1 , the following operations are performed:

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$$p_{35023} = p_{35023} \oplus i_1$$

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$$p_{21047} = p_{21047} \oplus i_1$$

$$p_{32213} = p_{32213} \oplus i_1$$

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$$p_{1172} = p_{1172} \oplus i_1$$

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$$p_{25731} = p_{25731} \oplus i_1$$

$$p_{16574} = p_{16574} \oplus i_1$$

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$$p_{16574} = p_{16574} \oplus i_1$$

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$$p_{5640} = p_{5640} \oplus i_1$$

$$p_{626} = p_{626} \oplus i_1$$

$$p_{37519} = p_{37519} \oplus i_1$$

$$p_{18638} = p_{18638} \oplus i_1$$

$$p_{21240} = p_{21240} \oplus i_1$$

[0027] For the 361st information bit i_{360} , the addresses of the parity bit accumulators are given in the second rows of Tables 1-3. In a similar manner the addresses of the parity bit accumulators for the following 359 information bits i_m , $m = 361, 362, \dots, 719$ are obtained using the formula $\{x + m \bmod 360 \times q\} \bmod (n_{ldpc} - k_{ldpc})$, where x denotes the address of the parity bit accumulator corresponding to the information bit i_{360} , i.e., the entries in the second row of the Tables 1-3. In a similar manner, for every group of 360 new information bits, a new row from Tables 1 - 3 are used to find the addresses of the parity bit accumulators.

Table 1

Address of Parity Bit Accumulators (Rate 1/3)												
34903	20927	32093	1052	25611	16093	16454	5520	506	37399	18518	21120	
11636	14594	22158	14763	15333	6838	22222	37856	14985	31041	18704	32910	
17449	1665	35639	16624	12867	12449	10241	11650	25622	34372	19878	26894	
29235	19780	36056	20129	20029	5457	8157	35554	21237	7943	13873	14980	
9912	7143	35911	12043	17360	37253	25588	11827	29152	21936	24125	40870	
40701	36035	39556	12366	19946	29072	16365	35495	22686	11106	8756	34863	
19165	15702	13536	40238	4465	40034	40590	37540	17162	1712	20577	14138	
31338	19342	9301	39375	3211	1316	33409	28670	12282	6118	29236	35787	
11504	30506	19558	5100	24188	24738	30397	33775	9699	6215	3397	37451	
34689	23126	7571	1058	12127	27518	23064	11265	14867	30451	28289	2966	
11660	15334	16867	15160	38343	3778	4265	39139	17293	26229	42604	13486	
31497	1365	14828	7453	26350	41346	28643	23421	8354	16255	11055	24279	
15687	12467	13906	5215	41328	23755	20800	6447	7970	2803	33262	39843	
5363	22469	38091	28457	36696	34471	23619	2404	24229	41754	1297	18563	
3673	39070	14480	30279	37483	7580	29519	30519	39831	20252	18132	20010	
34386	7252	27526	12950	6875	43020	31566	39069	18985	15541	40020	16715	
1721	37332	39953	17430	32134	29162	10490	12971	28581	29331	6489	35383	
736	7022	42349	8783	6767	11871	21675	10325	11548	25978	431	24085	
1925	10602	28585	12170	15156	34404	8351	13273	20208	5800	15367	21764	
16279	37832	34792	21250	34192	7406	41488	18346	29227	26127	25493	7048	
39948	28229	24899										
17408	14274	38993										
38774	15968	28459										
41404	27249	27425										
41229	6082	43114										
13957	4979	40654										
3093	3438	34992										
34082	6172	28760										
42210	34141	41021										
14705	17783	10134										

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(continued)

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Address of Parity Bit Accumulators (Rate 1/3)

41755 39884 22773
14615 15593 1642
29111 37061 39860
9579 33552 633
12951 21137 39608
38244 27361 29417
2939 10172 36479
29094 5357 19224
9562 24436 28637
40177 2326 13504
6834 21583 42516
40651 42810 25709
31557 32138 38142
18624 41867 39296
37560 14295 16245
6821 21679 31570
25339 25083 22081
8047 697 35268
9884 17073 19995
26848 35245 8390
18658 16134 14807
12201 32944 5035
25236 1216 38986
42994 24782 8681
28321 4932 34249
4107 29382 32124
22157 2624 14468
38788 27081 7936
4368 26148 10578
25353 4122 39751

Table 2

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Address of Parity Bit Accumulators (Rate 1/4)

23606 36098 1140 28859 18148 18510 6226 540 42014 20879 23802 47088
16419 24928 16609 17248 7693 24997 42587 16858 34921 21042 37024 20692
1874 40094 18704 14474 14004 11519 13106 28826 38669 22363 30255 31105
22254 40564 22645 22532 6134 9176 39998 23892 8937 15608 16854 31009
8037 40401 13550 19526 41902 28782 13304 32796 24679 27140 45980 10021
40540 44498 13911 22435 32701 18405 39929 25521 12497 9851 39223 34823
15233 45333 5041 44979 45710 42150 19416 1892 23121 15860 8832 10308
10468 44296 3611 1480 37581 32254 13817 6883 32892 40258 46538 11940
6705 21634 28150 43757 895 6547 20970 28914 30117 25736 41734 11392
22002 5739 27210 27828 34192 37992 10915 6998 3824 42130 4494 35739
8515 1191 13642 30950 25943 12673 16726 34261 31828 3340 8747 39225
18979 17058 43130 4246 4793 44030 19454 29511 47929 15174 24333 19354
16694 8381 29642 46516 32224 26344 9405 18292 12437 27316 35466 41992
15642 5871 46489 26723 23396 7257 8974 3156 37420 44823 35423 13541
42858 32008 41282 38773 26570 2702 27260 46974 1469 20887 27426 38553

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Address of Parity Bit Accumulators (Rate 1/4)

22152 24261 8297
 19347 9978 27802
 34991 6354 33561
 29782 30875 29523
 9278 48512 14349
 38061 4165 43878
 8548 33172 34410
 22535 28811 23950
 20439 4027 24186
 38618 8187 30947
 35538 43880 21459
 7091 45616 15063
 5505 9315 21908
 36046 32914 11836
 7304 39782 33721
 16905 29962 12980
 11171 23709 22460
 34541 9937 44500
 14035 47316 8815
 15057 45482 24461
 30518 36877 879
 7583 13364 24332
 448 27056 4682
 12083 31378 21670
 1159 18031 2221
 17028 38715 9350
 17343 24530 29574
 46128 31039 32818
 20373 36967 18345
 46685 20622 32806

Table 3

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Address of Parity Bit Accumulators (Rate 2/5)

31413 18834 28884 947 23050 14484 14809 4968 455 33659 16666 19008
 13172 19939 13354 13719 6132 20086 34040 13442 27958 16813 29619 16553
 1499 32075 14962 11578 11204 9217 10485 23062 30936 17892 24204 24885
 32490 18086 18007 4957 7285 32073 19038 7152 12486 13483 24808 21759
 32321 10839 15620 33521 23030 10646 26236 19744 21713 36784 8016 12869
 35597 11129 17948 26160 14729 31943 20416 10000 7882 31380 27858 33356
 14125 12131 36199 4058 35992 36594 33698 15475 1566 18498 12725 7067
 17406 8372 35437 2888 1184 30068 25802 11056 5507 26313 32205 37232
 15254 5365 17308 22519 35009 718 5240 16778 23131 24092 20587 33385
 27455 17602 4590 21767 22266 27357 30400 8732 5596 3060 33703 3596
 6882 873 10997 24738 20770 10067 13379 27409 25463 2673 6998 31378
 15181 13645 34501 3393 3840 35227 15562 23615 38342 12139 19471 15483
 13350 6707 23709 37204 25778 21082 7511 14588 10010 21854 28375 33591
 12514 4695 37190 21379 18723 5802 7182 2529 29936 35860 28338 10835
 34283 25610 33026 31017 21259 2165 21807 37578 1175 16710 21939 30841

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Address of Parity Bit Accumulators (Rate 2/5)	
5	27292 33730 6836 26476 27539 35784 18245 16394 17939 23094 19216 17432 11655 6183 38708 28408 35157 17089 13998 36029 15052 16617 5638 36464 15693 28923 26245 9432 11675 25720 26405 5838 31851 26898 8090 37037 24418 27583 7959 35562 37771 17784 11382 11156 37855 7073 21685 34515 10977 13633 30969 7516 11943 18199 5231 13825 19589 23661 11150 35602
10	19124 30774 6670 37344 16510 26317 23518 22957 6348 34069 8845 20175 34985 14441 25668 4116 3019 21049 37308 24551 24727 20104 24850 12114 38187 28527 13108 13985 1425 21477 30807 8613 26241 33368 35913 32477 5903 34390 24641 26556 23007 27305 38247 2621 9122 32806 21554 18685
15	17287 27292 19033 25796 31795 12152 12184 35088 31226 38263 33386 24892 23114 37995 29796
20	34336 10551 36245 35407 175 7203 14654 38201 22605 28404 6595 1018 19932 3524 29305
25	31749 20247 8128 18026 36357 26735 7543 29767 13588 13333 25965 8463 14504 36796 19710
30	4528 25299 7318 35091 25550 14798 7824 215 1248 30848 5362 17291
35	28932 30249 27073 13062 2103 16206 7129 32062 19612 9512 21936 38833 35849 33754 23450
40	18705 28656 18111 22749 27456 32187 28229 31684 30160 15293 8483 28002
45	14880 13334 12584 28646 2558 19687 6259 4499 26336 11952 28386 8405 10609 961 7582
50	10423 13191 26818 15922 36654 21450 10492 1532 1205 30551 36482 22153
55	5156 11330 34243 28616 35369 13322 8962 1485 21186

(continued)

Address of Parity Bit Accumulators (Rate 2/5)

23541 17445 35561
33133 11593 19895
33917 7863 33651
20063 28331 10702
13195 21107 21859
4364 31137 4804
5585 2037 4830
30672 16927 14800

[0028] After all of the information bits are exhausted, the final parity bits are obtained as follows. First, the following operations are performed, starting with $i = 1$

$$p_i = p_i \oplus p_{i-1},$$

$i=1,2,\dots,n_{ldpc}-k_{ldpc}-1$.

Final content of p_i , $i = 0,1,\dots,n_{ldpc} - k_{ldpc} - 1$ is equal to the parity bit p_i .

[0029] After all of the information bits are exhausted, the final parity bits are obtained as follows. First, the following operations are performed, starting with $i = 1$

$$p_i = p_i \oplus p_{i-1},$$

$i=1,2,\dots,n_{ldpc}-k_{ldpc}-1$.

Final content of p_i , $i = 0,1,\dots,n_{ldpc} - k_{ldpc} - 1$ is equal to the parity bit p_i .

[0030] As regards BCH encoding, according to one embodiment of the present invention, the generator polynomial of the BCH code utilized by the BCH encoder 211 is as follows:

$$\begin{aligned} g(x) = & (1+x+x^3+x^5+x^{14}) \times (1+x^6+x^8+x^{11}+x^{14}) \times (1+x+x^2+x^6+x^9+x^{10}+x^{14}) \times \\ & (1+x^4+x^7+x^8+x^{10}+x^{12}+x^{14}) \times (1+x^2+x^4+x^6+x^8+x^9+x^{11}+x^{13}+x^{14}) \times \\ & (1+x^3+x^7+x^8+x^9+x^{13}+x^{14}) \times (1+x^2+x^5+x^6+x^7+x^{10}+x^{11}+x^{13}+x^{14}) \times \\ & (1+x^5+x^8+x^9+x^{10}+x^{11}+x^{14}) \times (1+x+x^2+x^3+x^9+x^{10}+x^{14}) \times (1+x^3+x^6+x^9+x^{11}+x^{12}+x^{14}) \times \\ & (1+x^4+x^{11}+x^{12}+x^{14}) \times (1+x+x^2+x^3+x^5+x^6+x^7+x^8+x^{10}+x^{13}+x^{14}). \end{aligned}$$

[0031] BCH encoding of information bits $m = (m_{k_{bch}-1}, m_{k_{bch}-2}, \dots, m_1, m_0)$ onto a codeword $c = (m_{k_{bch}-1}, m_{k_{bch}-2}, \dots, m_1, m_0, d_{n_{bch}-k_{bch}-1}, d_{n_{bch}-k_{bch}-2}, \dots, d_1, d_0)$ is achieved as follows. The message polynomial $m(x) = m_{k_{bch}-1}x^{k_{bch}-1} + m_{k_{bch}-2}x^{k_{bch}-2} + \dots + m_1x + m_0$ is multiplied by $x^{n_{bch}-k_{bch}}$. Next, $X^{n_{bch}-k_{bch}} m(x)$ divided by $g(x)$. With $d(x) = d_{n_{bch}-k_{bch}-1}x^{n_{bch}-k_{bch}-1} + \dots + d_1x + d_0$ as the remainder, the codeword polynomial is set as follows: $c(x) = X^{n_{bch}-k_{bch}} m(x) + d(x)$.

[0032] As discussed, k_{ldpc} bits are systematically encoded to generate n_{ldpc} bits. According to one embodiment of the present invention, n_{ldpc} is 16200 bits, which is a short block length. Given the relatively short length of such codes, LDPC codes having approximate lengths of 16200 bits or less are deemed "short" block length codes.

[0033] In accordance with an embodiment of the present invention, some of the short blocks codes (e.g., rate 1/5 of Table 5) are generated by shortening versions of slightly longer (k_m, n_m) "mother" codes of block size $n_m > 16200$. As shown in FIG. 2D, k_{ldpc} of the BCH encoded bits are preceded by $k_m - k_{ldpc}$ dummy zeros (per step 251). The resulting k_m bits are systematically encoded to generate n_m bits, as in step 253. The first $k_m - k_{ldpc}$ dummy zeros are then deleted, as in step 255, and the resulting $n_{ldpc} = 16200$ bits will be transmitted (step 257). It is noted that $k_m - k_{ldpc} = n_m - n_{ldpc}$.

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Tables 4-6 provide other exemplary short code rates, 1/3, 1/5 and 2/5 (n_{ldpc} of 16200 bits):

Table 4

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Address of Parity Bit Accumulators (Rate 1/3)															
416	8909	4156	3216	3112	2560	2912	6405	8593	4969	6723	6912				
8978	3011	4339	9312	6396	2957	7288	5485	6031	10218	2226	3575				
3383	10059	1114	10008	10147	9384	4290	434	5139	3536	1965	2291				
2797	3693	7615	7077	743	1941	8716	6215	3840	5140	4582	5420				
6110	8551	1515	7404	4879	4946	5383	1831	3441	9569	10472	4306				
1505	5682	7778													
7172	6830	6623													
7281	3941	3505													
10270	8669	914													
3622	7563	9388													
9930	5058	4554													
4844	9609	2707													
6883	3237	1714													
4768	3878	10017													
10127	3334	8267													

Table 5

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Address of Parity Bit Accumulators (Rate 1/5: Shortened from Rate 1/4)															
6295	9626	304	7695	4839	4936	1660	144	11203	5567	6347	12557				
10691	4988	3859	3734	3071	3494	7687	10313	5964	8069	8296	11090				
10774	3613	5208	11177	7676	3549	8746	6583	7239	12265	2674	4292				
11869	3708	5981	8718	4908	10650	6805	3334	2627	10461	9285	11120				
7844	3079	10773													
3385	10854	5747													
1360	12010	12202													
6189	4241	2343													
9840	12726	4977													

Table 6

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Address of Parity Bit Accumulators (Rate 2/5)															
5650	4143	8750	583	6720	8071	635	1767	1344	6922	738	6658				
5696	1685	3207	415	7019	5023	5608	2605	857	6915	1770	8016				
3992	771	2190	7258	8970	7792	1802	1866	6137	8841	886	1931				
4108	3781	7577	6810	9322	8226	5396	5867	4428	8827	7766	2254				
4247	888	4367	8821	9660	324	5864	4774	227	7889	6405	8963				
9693	500	2520	2227	1811	9330	1928	5140	4030	4824	806	3134				
1652	8171	1435													
3366	6543	3745													
9286	8509	4645													
7397	5790	8972													
6597	4422	1799													
9276	4041	3847													
8683	7378	4946													
5348	1993	9186													

(continued)

Address of Parity Bit Accumulators (Rate 2/5)

6724 9015 5646
4502 4439 8474
5107 7342 9442
1387 8910 2660

[0034] The above approach to designing LDPC codes, as provided in Tables 1-6, advantageously permits storage and retrieval of relevant information regarding partitioned groups of bit nodes and check nodes to be always placed in contiguous memory locations within memory (e.g., Random Access Memory (RAM)). Consequently, multiple code rates can be supported without employing different decoders. Further, the design enables use of a single RAM bank, thereby minimizing size of the integrated circuit. As mentioned, the above LDPC codes, in an exemplary embodiment, can be used to variety of digital video applications, such as MPEG (Motion Pictures Expert Group) packet transmission.

[0035] FIG. 3 is a diagram of an exemplary receiver in the system of FIG. 1. At the receiving side, a receiver 300 includes a demodulator 301 that performs demodulation of received signals from transmitter 200. These signals are received at a receive antenna 303 for demodulation. After demodulation, the received signals are forwarded to a LDPC decoder 305, which attempts to reconstruct the original source messages by generating messages, X' , in conjunction with a bit metric generator 307. The bit metric generator 307 may exchange information with the decoder 305 back and forth (iteratively) during the decoding process. These decoding approaches are more fully described in co-pending application, entitled "Method and System for Routing in Low Density Parity Check (LDPC) Decoders," filed July 3, 2003 (Serial No. 10/613,824; Attorney Docket PD-203009). It is noted that LDPC codes, as constructed per Tables 1-6, can support multiple code rates (consequently, multiple data rates) using a common decoding architecture; in contrast, convolutional codes, for example, require puncturing techniques to achieve intermediate rates.

[0036] To further appreciate the advantages offered by the present invention, it is instructive to examine how LDPC codes are generated, as discussed in FIG. 4.

[0037] FIG. 4 is a diagram of a sparse parity check matrix, in accordance with an embodiment of the present invention. LDPC codes are long, linear block codes with sparse parity check matrix $H_{(n-k) \times n}$. Typically the block length, n , ranges from thousands to tens of thousands of bits. For example, a parity check matrix for an LDPC code of length $n=8$ and rate $1/2$ is shown in FIG. 4. The same code can be equivalently represented by the bipartite graph, per FIG. 5.

[0038] FIG. 5 is a diagram of a bipartite graph of an LDPC code of the matrix of FIG. 4. Parity check equations imply that for each check node, the sum (over GF (Galois Field)(2)) of all adjacent bit nodes is equal to zero. As seen in the figure, bit nodes occupy the left side of the graph and are associated with one or more check nodes, according to a predetermined relationship. For example, corresponding to check node m_1 , the following expression exists $n_1 + n_4 + n_5 + n_8 = 0$ with respect to the bit nodes.

[0039] Returning to the receiver 300, the LDPC decoder 305 is considered a message passing decoder, whereby the decoder 305 aims to find the values of bit nodes. To accomplish this task, bit nodes and check nodes iteratively communicate with each other. The nature of this communication is described below.

[0040] From check nodes to bit nodes, each check node provides to an adjacent bit node an estimate ("opinion") regarding the value of that bit node based on the information coming from other adjacent bit nodes. For instance, in the above example if the sum of n_4 , n_5 and n_8 "looks like" 0 to m_1 , then m_1 would indicate to n_1 that the value of n_1 is believed to be 0 (since $n_1 + n_4 + n_5 + n_8 = 0$); otherwise m_1 indicate to n_1 that the value of n_1 is believed to be 1. Additionally, for soft decision decoding, a reliability measure is added.

[0041] From bit nodes to check nodes, each bit node relays to an adjacent check node an estimate about its own value based on the feedback coming from its other adjacent check nodes. In the above example n_1 has only two adjacent check nodes m_1 and m_3 . If the feedback coming from m_3 to n_1 indicates that the value of n_1 is probably 0, then n_1 would notify m_1 that an estimate of n_1 's own value is 0. For the case in which the bit node has more than two adjacent check nodes, the bit node performs a majority vote (soft decision) on the feedback coming from its other adjacent check nodes before reporting that decision to the check node it communicates. The above process is repeated until all bit nodes are considered to be correct (i.e., all parity check equations are satisfied) or until a predetermined maximum number of iterations is reached, whereby a decoding failure is declared.

[0042] FIG. 6 is a diagram of a sub-matrix of a sparse parity check matrix, wherein the sub-matrix contains parity check values restricted to the lower triangular region, according to an embodiment of the present invention. As described previously, the encoder 203 (of FIGs. 2A and 2B) can employ a simple encoding technique by restricting the values of the lower triangular area of the parity check matrix. According to an embodiment of the present invention, the restriction imposed on the parity check matrix is of the form:

$$H_{(n-k)xn} = [A_{(n-k)xt} B_{(n-k)x(n-k)}]$$

, where B is lower triangular.

[0043] Any information block $i=(i_0, i_1, \dots, i_{k-1})$ is encoded to a codeword $c=(i_0, i_1, \dots, i_{k-1}, p_0, p_1, \dots, p_{n-k-1})$ using $Hc^T = 0$, and recursively solving for parity bits; for example,

$$a_{00}i_0 + a_{01}i_1 + \dots + a_{0,k-1}i_{k-1} + p_0 = 0 \Rightarrow \text{Solve } p_0 \quad ,$$

$$a_{10}i_0 + a_{11}i_1 + \dots + a_{1,k-1}i_{k-1} + b_{10}p_0 + p_1 = 0 \Rightarrow \text{Solve } p_1$$

and similarly for $p_2, p_3, \dots, p_{n-k-1}$.

[0044] FIGs. 7 and 8 are graphs of performance of the LDPC codes at the various code rates and modulation schemes supported by the transmitter 200 of FIG. 2A. Specifically, the graph of FIG. 7 shows a performance comparison between rate 1/3 and 1/4 LDPC codes and repetition rate 2/3 and repetition rate 1/2 LDPC codes, respectively. Under this scenario, performance is considered in the case of rate 1/3 and 1/4 for QPSK LDPC codes on an Additive White Gaussian Noise (AWGN) channel. As seen, the rate 1/3 code offers about 1.3 dB gain with respect to a repetition rate 2/3 LDPC code, whereas rate 1/4 LDPC code offers about 0.4 dB gain with respect to a repetition rate 1/2 LDPC code. Repetition codes are constructed by repeating the source information bits as the set of parity bits. Therefore rate 1/3 and 1/4 LDPC codes would offer performance advantage with respect to repetition codes when used in low priority branch of backward compatible hierarchical modulation schemes.

[0045] FIG. 8 illustrates the performance of short frame length codes of rates 1/5, 1/3 and 2/5 along with the long frame length codes of rates 1/4, 1/3 and 2/5. As shown, the short codes for rates 1/3 and 2/5 exhibit nearly comparable performance to their counterpart long codes (within 0.2 dB).

[0046] The LDPC encoding processes as detailed above can be executed through a variety of hardware and/or software configurations. In fact, this approach also can be readily deployed solely through a software change, thereby eliminating costly hardware modifications.

[0047] FIG. 9 illustrates exemplary hardware upon which an embodiment according to the present invention can be implemented. A computing system 900 includes a bus 901 or other communication mechanism for communicating information and a processor 903 coupled to the bus 901 for processing information. The computing system 900 also includes main memory 905, such as a random access memory (RAM) or other dynamic storage device, coupled to the bus 901 for storing information and instructions to be executed by the processor 903. Main memory 905 can also be used for storing temporary variables or other intermediate information during execution of instructions by the processor 903. The computing system 900 may further include a read only memory (ROM) 907 or other static storage device coupled to the bus 901 for storing static information and instructions for the processor 903. A storage device 909, such as a magnetic disk or optical disk, is coupled to the bus 901 for persistently storing information and instructions.

[0048] The computing system 900 may be coupled via the bus 901 to a display 911, such as a liquid crystal display, or active matrix display, for displaying information to a user. An input device 913, such as a keyboard including alpha-numeric and other keys, may be coupled to the bus 901 for communicating information and command selections to the processor 903. The input device 913 can include a cursor control, such as a mouse, a trackball, or cursor direction keys, for communicating direction information and command selections to the processor 903 and for controlling cursor movement on the display 911.

[0049] According to one embodiment of the invention, the processes of FIGs. 2C and 2D can be provided by the computing system 900 in response to the processor 903 executing an arrangement of instructions contained in main memory 905. Such instructions can be read into main memory 905 from another computer-readable medium, such as the storage device 909. Execution of the arrangement of instructions contained in main memory 905 causes the processor 903 to perform the process steps described herein. One or more processors in a multi-processing arrangement may also be employed to execute the instructions contained in main memory 905. In alternative embodiments, hard-wired circuitry may be used in place of or in combination with software instructions to implement the embodiment of the present invention. In another example, reconfigurable hardware such as Field Programmable Gate Arrays (FPGAs) can be used, in which the functionality and connection topology of its logic gates are customizable at run-time, typically by programming memory look up tables. Thus, embodiments of the present invention are not limited to any specific combination of

hardware circuitry and software.

[0050] The computing system 900 also includes at least one communication interface 915 coupled to bus 901. The communication interface 915 provides a two-way data communication coupling to a network link (not shown). The communication interface 915 sends and receives electrical, electromagnetic, or optical signals that carry digital data streams representing various types of information. Further, the communication interface 915 can include peripheral interface devices, such as a Universal Serial Bus (USB) interface, a PCMCIA (Personal Computer Memory Card International Association) interface, etc.

[0051] The processor 903 may execute code that is being received over the communication interface 915 and/or store the code in the storage device 909, or other non-volatile storage for later execution. In this manner, the computing system 900 may obtain application code in the form of a carrier wave.

[0052] The term "computer-readable medium" as used herein refers to any medium that participates in providing instructions to the processor 903 for execution. Such a medium may take many forms, including but not limited to non-volatile media, volatile media, and transmission media. Non-volatile media include, for example, optical or magnetic disks, such as the storage device 909. Volatile media include dynamic memory, such as main memory 905. Transmission media include coaxial cables, copper wire and fiber optics, including the wires that comprise the bus 901. Transmission media can also take the form of acoustic, optical, or electromagnetic waves, such as those generated during radio frequency (RF) and infrared (IR) data communications. Common forms of computer-readable media include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a CD-ROM, CDRW, DVD, any other optical medium, punch cards, paper tape, optical mark sheets, any other physical medium with patterns of holes or other optically recognizable indicia, a RAM, a PROM, and EPROM, a FLASH-EPROM, any other memory chip or cartridge, a carrier wave, or any other medium from which a computer can read.

[0053] Various forms of computer-readable media may be involved in providing instructions to a processor for execution. For example, the instructions for carrying out at least part of the present invention may initially be borne on a magnetic disk of a remote computer. In such a scenario, the remote computer loads the instructions into main memory and sends the instructions over a telephone line using a modem. A modem of a local system receives the data on the telephone line and uses an infrared transmitter to convert the data to an infrared signal and transmit the infrared signal to a portable computing device, such as a personal digital assistant (PDA) or a laptop. An infrared detector on the portable computing device receives the information and instructions borne by the infrared signal and places the data on a bus. The bus conveys the data to main memory, from which a processor retrieves and executes the instructions. The instructions received by main memory can optionally be stored on storage device either before or after execution by processor.

[0054] Accordingly, the various embodiments of the present invention provide an LDPC encoder generates a LDPC code having an outer Bose Chaudhuri Hocquenghem (BCH) code according to one of Tables 1-6 for transmission as a LDPC coded signal. Each of the Tables 1-6 specifies the address of parity bit accumulators. The above approach advantageously yields reduced complexity without sacrificing performance.

[0055] While the present invention has been described in connection with a number of embodiments and implementations, the present invention is not so limited but covers various obvious modifications and equivalent arrangements, which fall within the purview of the appended claims.

Claims

1. A method for encoding, comprising:

receiving information bits; and

generating, based on the information bits, parity bits of a Low Density Parity Check (LDPC) code according to one of a code rate of 1/3, a code rate of 1/4, or a code rate of 2/5 by accumulating bits at parity bit addresses as specified by the following respective tables using parity bit accumulators,

Address of Parity Bit Accumulators (Rate 1/3)

34903	20927	32093	1052	25611	16093	16454	5520	506	37399	18518	21120
11636	14594	22158	14763	15333	6838	22222	37856	14985	31041	18704	32910
17449	1665	35639	16624	12867	12449	10241	11650	25622	34372	19878	26894
29235	19780	36056	20129	20029	5457	8157	35554	21237	7943	13873	14980
9912	7143	35911	12043	17360	37253	25588	11827	29152	21936	24125	40870
40701	36035	39556	12366	19946	29072	16365	35495	22686	11106	8756	34863
19165	15702	13536	40238	4465	40034	40590	37540	17162	1712	20577	14138

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(continued)

Address of Parity Bit Accumulators (Rate 1/3)	
5	31338 19342 9301 39375 3211 1316 33409 28670 12282 6118 29236 35787 11504 30506 19558 5100 24188 24738 30397 33775 9699 6215 3397 37451 34689 23126 7571 1058 12127 27518 23064 11265 14867 30451 28289 2966 11660 15334 16867 15160 38343 3778 4265 39139 17293 26229 42604 13486 31497 1365 14828 7453 26350 41346 28643 23421 8354 16255 11055 24279
10	15687 12467 13906 5215 41328 23755 20800 6447 7970 2803 33262 39843 5363 22469 38091 28457 36696 34471 23619 2404 24229 41754 1297 18563 3673 39070 14480 30279 37483 7580 29519 30519 39831 20252 18132 20010 34386 7252 27526 12950 6875 43020 31566 39069 18985 15541 40020 16715 1721 37332 39953 17430 32134 29162 10490 12971 28581 29331 6489 35383
15	736 7022 42349 8783 6767 11871 21675 10325 11548 25978 431 24085 1925 10602 28585 12170 15156 34404 8351 13273 20208 5800 15367 21764 16279 37832 34792 21250 34192 7406 41488 18346 29227 26127 25493 7048 39948 28229 24899
20	17408 14274 38993 38774 15968 28459 41404 27249 27425 41229 6082 43114 13957 4979 40654
25	3093 3438 34992 34082 6172 28760 42210 34141 41021 14705 17783 10134 41755 39884 22773
30	14615 15593 1642 29111 37061 39860 9579 33552 633 12951 21137 39608
35	38244 27361 29417 2939 10172 36479 29094 5357 19224 9562 24436 28637
40	40177 2326 13504 6834 21583 42516 40651 42810 25709 31557 32138 38142 18624 41867 39296
45	37560 14295 16245 6821 21679 31570 25339 25083 22081 8047 697 35268
50	9884 17073 19995 26848 35245 8390 18658 16134 14807 12201 32944 5035 25236 1216 38986
55	42994 24782 8681 28321 4932 34249 4107 29382 32124

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(continued)

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Address of Parity Bit Accumulators (Rate 1/3)			
22157	2624	14468	
38788	27081	7936	
4368	26148	10578	
25353	4122	39751	

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Address of Parity Bit Accumulators (Rate 1/4)															
23606	36098	1140	28859	18148	18510	6226	540	42014	20879	23802	47088				
16419	24928	16609	17248	7693	24997	42587	16858	34921	21042	37024	20692				
1874	40094	18704	14474	14004	11519	13106	28826	38669	22363	30255	31105				
22254	40564	22645	22532	6134	9176	39998	23892	8937	15608	16854	31009				
8037	40401	13550	19526	41902	28782	13304	32796	24679	27140	45980	10021				
40540	44498	13911	22435	32701	18405	39929	25521	12497	9851	39223	34823				
15233	45333	5041	44979	45710	42150	19416	1892	23121	15860	8832	10308				
10468	44296	3611	1480	37581	32254	13817	6883	32892	40258	46538	11940				
6705	21634	28150	43757	895	6547	20970	28914	30117	25736	41734	11392				
22002	5739	27210	27828	34192	37992	10915	6998	3824	42130	4494	35739				
8515	1191	13642	30950	25943	12673	16726	34261	31828	3340	8747	39225				
18979	17058	43130	4246	4793	44030	19454	29511	47929	15174	24333	19354				
16694	8381	29642	46516	32224	26344	9405	18292	12437	27316	35466	41992				
15642	5871	46489	26723	23396	7257	8974	3156	37420	44823	35423	13541				
42858	32008	41282	38773	26570	2702	27260	46974	1469	20887	27426	38553				
22152	24261	8297													
19347	9978	27802													
34991	6354	33561													
29782	30875	29523													
9278	48512	14349													
38061	4165	43878													
8548	33172	34410													
22535	28811	23950													
20439	4027	24186													
38618	8187	30947													
35538	43880	21459													
7091	45616	15063													
5505	9315	21908													
36046	32914	11836													
7304	39782	33721													
16905	29962	12980													
11171	23709	22460													
34541	9937	44500													
14035	47316	8815													
15057	45482	24461													
30518	36877	879													
7583	13364	24332													
448	27056	4682													
12083	31378	21670													
1159	18031	2221													
17028	38715	9350													
17343	24530	29574													

(continued)

Address of Parity Bit Accumulators (Rate 1/4)

46128 31039 32818
 20373 36967 18345
 46685 20622 32806

Address of Parity Bit Accumulators (Rate 2/5)

5650 4143 8750 583 6720 8071 635 1767 1344 6922 738 6658
 5696 1685 3207 415 7019 5023 5608 2605 857 6915 1770 8016
 3992 771 2190 7258 8970 7792 1802 1866 6137 8841 886 1931
 4108 3781 7577 6810 9322 8226 5396 5867 4428 8827 7766 2254
 4247 888 4367 8821 9660 324 5864 4774 227 7889 6405 8963
 9693 500 2520 2227 1811 9330 1928 5140 4030 4824 806 3134
 1652 8171 1435
 3366 6543 3745
 9286 8509 4645
 7397 5790 8972
 6597 4422 1799
 9276 4041 3847
 8683 7378 4946
 5348 1993 9186
 6724 9015 5646
 4502 4439 8474
 5107 7342 9442
 1387 8910 2660

2. A method according to claim 1, further comprising:

modulating the LDPC coded signal; and
 transmitting the modulated signal.

3. A method according to claim 2, wherein the modulated signal is transmitted over a satellite link (103) in support of a broadband satellite application.

4. A method according to claim 2, wherein the modulating step is performed according to a signal constellation that includes one of 8-PSK, 16-QAM, QPSK, 16-APSK or 32-APSK whereby PSK denotes Phase Shift keying, QAM denotes Quadrature Amplitude Modulation, QPSK denotes Quadrature Phase Shift keying and APSK denotes Amplitude Phase Shift keying.

5. A computer-readable medium bearing instructions for encoding, said instruction, being arranged, upon execution, to cause one or more processors to perform the method of claim 1.

6. An encoder (203) comprising:

means for receiving information bits; and
 means for generating, based on the information bits, a Low Density Parity Check (LDPC) code according to one of a plurality of code rates by accumulating bits at parity bit addresses as specified by the following respective tables using parity bit accumulators,

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Address of Parity Bit Accumulators (Rate 1/3)	
5	34903 20927 32093 1052 25611 16093 16454 5520 506 37399 18518 21120 11636 14594 22158 14763 15333 6838 22222 37856 14985 31041 18704 32910 17449 1665 35639 16624 12867 12449 10241 11650 25622 34372 19878 26894 29235 19780 36056 20129 20029 5457 8157 35554 21237 7943 13873 14980 9912 7143 35911 12043 17360 37253 25588 11827 29152 21936 24125 40870 40701 36035 39556 12366 19946 29072 16365 35495 22686 11106 8756 34863
10	19165 15702 13536 40238 4465 40034 40590 37540 17162 1712 20577 14138 31338 1934 29301 39375 3211 1316 33409 28670 12282 6118 29236 35787 11504 30506 19558 5100 24188 24738 30397 33775 9699 6215 3397 37451 34689 23126 7571 1058 12127 27518 23064 11265 14867 30451 28289 2966 11660 15334 16867 15160 38343 3778 4265 39139 17293 26229 42604 13486
15	31497 1365 14828 7453 26350 41346 28643 23421 8354 16255 11055 24279 15687 12467 13906 5215 41328 23755 20800 6447 7970 2803 33262 39843 5363 22469 38091 28457 36696 34471 23619 2404 24229 41754 1297 18563 3673 39070 14480 30279 37483 7580 29519 30519 39831 20252 18132 20010
20	34386 7252 27526 12950 6875 43020 31566 39069 18985 15541 40020 16715 1721 37332 39953 17430 32134 29162 10490 12971 28581 29331 6489 35383 736 7022 42349 8783 6767 11871 21675 10325 11548 25978 431 24085 1925 10602 28585 12170 15156 34404 8351 13273 20208 5800 15367 21764 16279 37832 34792 21250 34192 7406 41488 18346 29227 26127 25493 7048
25	39948 28229 24899 17408 14274 38993 38774 15968 28459 41404 27249 27425
30	41229 6082 43114 13957 4979 40654 3093 3438 34992 34082 6172 28760 42210 34141 41021
35	14705 17783 10134 41755 39884 22773 14615 15593 1642 29111 37061 39860 9579 33552 633
40	12951 21137 39608 38244 27361 29417 2939 10172 36479 29094 5357 19224
45	9562 24436 28637 40177 2326 13504 6834 21583 42516 40651 42810 25709
50	31557 32138 38142 18624 41867 39296 37560 14295 16245 6821 21679 31570 25339 25083 22081
55	8047 697 35268 9884 17073 19995 26848 35245 8390

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(continued)

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Address of Parity Bit Accumulators (Rate 1/3)			
18658	16134	14807	
12201	32944	5035	
25236	1216	38986	
42994	24782	8681	
28321	4932	34249	
4107	29382	32124	
22157	2624	14468	
38788	27081	7936	
4368	26148	10578	
25353	4122	39751	

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Address of Parity Bit Accumulators (Rate 1/4)											
23606	36098	1140	28859	18148	18510	6226	540	42014	20879	23802	47088
16419	24928	16609	17248	7693	24997	42587	16858	34921	21042	37024	20692
1874	40094	18704	14474	14004	11519	13106	28826	38669	22363	30255	31105
22254	40564	22645	22532	6134	9176	39998	23892	8937	15608	16854	31009
8037	40401	13550	19526	41902	28782	13304	32796	24679	27140	45980	10021
40540	44498	13911	22435	32701	18405	39929	25521	12497	9851	39223	34823
15233	45333	5041	44979	45710	42150	19416	1892	23121	15860	8832	10308
10468	44296	3611	1480	37581	32254	13817	6883	32892	40258	46538	11940
6705	21634	28150	43757	895	6547	20970	28914	30117	25736	41734	11392
22002	5739	27210	27828	34192	37992	10915	6998	3824	42130	4494	35739
8515	1191	13642	30950	25943	12673	16726	34261	31828	3340	8747	39225
18979	17058	43130	4246	4793	44030	19454	29511	47929	15174	24333	19354
16694	8381	29642	46516	32224	26344	9405	18292	12437	27316	35466	41992
15642	5871	46489	26723	23396	7257	8974	3156	37420	44823	35423	13541
42858	32008	41282	38773	26570	2702	27260	46974	1469	20887	27426	38553
22152	24261	8297									
19347	9978	27802									
34991	6354	33561									
29782	30875	29523									
9278	48512	14349									
38061	4165	43878									
8548	33172	34410									
22535	28811	23950									
20439	4027	24186									
38618	8187	30947									
35538	43880	21459									
7091	45616	15063									
5505	9315	21908									
36046	32914	11836									
7304	39782	33721									
16905	29962	12980									
11171	23709	22460									
34541	9937	44500									
14035	47316	8815									
15057	45482	24461									
30518	36877	879									

(continued)

Address of Parity Bit Accumulators (Rate 1/4)

7583 13364 24332
 448 27056 4682
 12083 31378 21670
 1159 18031 2221
 17028 38715 9350
 17343 24530 29574
 46128 31039 32818
 20373 36967 18345
 46685 20622 32806

Address of Parity Bit Accumulators (Rate 2/5)

5650 4143 8750 583 6720 8071 635 1767 1344 6922 738 6658
 5696 1685 3207 415 7019 5023 5608 2605 857 6915 1770 8016
 3992 771 2190 7258 8970 7792 1802 1866 6137 8841 886 1931
 4108 3781 7577 6810 9322 8226 5396 5867 4428 8827 7766 2254
 4247 888 4367 8821 9660 324 5864 4774 227 7889 6405 8963
 9693 500 2520 2227 1811 9330 1928 5140 4030 4824 806 3134
 1652 8171 1435
 3366 6543 3745
 9286 8509 4645
 7397 5790 8972
 6597 4422 1799
 9276 4041 3847
 8683 7378 4946
 5348 1993 9186
 6724 9015 5646
 4502 4439 8474
 5107 7342 9442
 1387 8910 2660

; and

means for generating an outer Bose Chaudhuri Hocquenghem (BCH) code for the LDPC code.

7. An encoder (203) according to claim 6, wherein the LDPC coded signal is modulated and transmitted.
8. An encoder (203) according to claim 7, wherein the modulated signal is in support of a broadband satellite application.
9. An encoder (203) according to claim 7, wherein the modulation is performed according to a signal constellation that includes one of 8-PSK, 16-QAM, QPSK, 16-APSK or 32-APSK, whereby PSK denotes Phase Shift keying, QAM denotes Quadrature Amplitude Modulation, QPSK denotes Quadrature Phase Shift keying and APSK denotes Amplitude Phase Shift keying.
10. A transmitter (200) for supporting transmission of a Low Density Parity Check (LDPC) coded signal, comprising:
 - a Low Density Parity Check (LDPC) encoder (203) configured to output, based on received information bits, an LDPC code; and
 - a Bose Chaudhuri Hocquenghem (BCH) encoder (211) coupled to the LDPC encoder (203) and configured to provide an outer code to the LDPC code, wherein the LDPC code is generated according to one of a code rate of 1/3, a code rate of 1/4, or a code rate of 2/5 by accumulating bits at parity bit addresses as specified by the

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following respective tables using parity bit accumulators,

Address of Parity Bit Accumulators (Rate 1/3)	
5	34903 20927 32093 1052 25611 16093 16454 5520 506 37399 18518 21120 11636 14594 22158 14763 15333 6838 22222 37856 14985 31041 18704 32910 17449 1665 35639 16624 12867 12449 10241 11650 25622 34372 19878 26894 29235 19780 36056 20129 20029 5457 8157 35554 21237 7943 13873 14980 9912 7143 35911 12043 17360 37253 25588 11827 29152 21936 24125 40870
10	40701 36035 39556 12366 19946 29072 16365 35495 22686 11106 8756 34863 19165 15702 13536 40238 4465 40034 40590 37540 17162 1712 20577 14138 31338 19342 9301 39375 3211 1316 33409 28670 12282 6118 29236 35787 11504 30506 19558 5100 24188 24738 30397 33775 9699 6215 3397 37451
15	34689 23126 7571 1058 12127 27518 23064 11265 14867 30451 28289 2966 11660 15334 16867 15160 38343 3778 4265 39139 17293 26229 42604 13486 31497 1365 14828 7453 26350 41346 28643 23421 8354 16255 11055 24279 15687 12467 13906 5215 41328 23755 20800 6447 7970 2803 33262 39843 5363 22469 38091 28457 36696 34471 23619 2404 24229 41754 1297 18563
20	3673 39070 14480 30279 37483 7580 29519 30519 39831 20252 18132 20010 34386 7252 27526 12950 6875 43020 31566 39069 18985 15541 40020 16715 1721 37332 39953 17430 32134 29162 10490 12971 28581 29331 6489 35383 736 7022 42349 8783 6767 11871 21675 10325 11548 25978 431 24085
25	1925 10602 28585 12170 15156 34404 8351 13273 20208 5800 15367 21764 16279 37832 34792 21250 34192 7406 41488 18346 29227 26127 25493 7048 39948 28229 24899 17408 14274 38993 38774 15968 28459
30	41404 27249 27425 41229 6082 43114 13957 4979 40654 3093 3438 34992 34082 6172 28760
35	42210 34141 41021 14705 17783 10134 41755 39884 22773 14615 15593 1642
40	29111 37061 39860 9579 33552 633 12951 21137 39608 38244 27361 29417
45	2939 10172 36479 29094 5357 19224 9562 24436 28637 40177 2326 13504 6834 21583 42516
50	40651 42810 25709 31557 32138 38142 18624 41867 39296 37560 14295 16245 6821 21679 31570
55	25339 25083 22081 8047 697 35268 9884 17073 19995

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(continued)

Address of Parity Bit Accumulators (Rate 1/3)	
5	26848 35245 8390
	18658 16134 14807
	12201 32944 5035
	25236 1216 38986
	42994 24782 8681
10	28321 4932 34249
	4107 29382 32124
	22157 2624 14468
	38788 27081 7936
	4368 26148 10578
15	25353 4122 39751

Address of Parity Bit Accumulators (Rate 1/4)	
20	23606 36098 1140 28859 18148 18510 6226 540 42014 20879 23802 47088
	16419 24928 16609 17248 7693 24997 42587 16858 34921 21042 37024 20692
	1874 40094 18704 14474 14004 11519 13106 28826 38669 22363 30255 31105
	22254 40564 22645 22532 6134 9176 39998 23892 8937 15608 16854 31009
25	8037 40401 13550 19526 41902 28782 13304 32796 24679 27140 45980 10021
	40540 44498 13911 22435 32701 18405 39929 25521 12497 9851 39223 34823
	15233 45333 5041 44979 45710 42150 19416 1892 23121 15860 8832 10308
	10468 44296 3611 1480 37581 32254 13817 6883 32892 40258 46538 11940
	6705 21634 28150 43757 895 6547 20970 28914 30117 25736 41734 11392
30	22002 5739 27210 27828 34192 37992 10915 6998 3824 42130 4494 35739
	8515 1191 13642 30950 25943 12673 16726 34261 31828 3340 8747 39225
	18979 17058 43130 4246 4793 44030 19454 29511 47929 15174 24333 19354
	16694 8381 29642 46516 32224 26344 9405 18292 12437 27316 35466 41992
35	15642 5871 46489 26723 23396 7257 8974 3156 37420 44823 35423 13541
	42858 32008 41282 38773 26570 2702 27260 46974 1469 20887 27426 38553
	22152 24261 8297
	19347 9978 27802
	34991 6354 33561
40	29782 30875 29523
	9278 48512 14349
	38061 4165 43878
	8548 33172 34410
45	22535 28811 23950
	20439 4027 24186
	38618 8187 30947
	35538 43880 21459
	7091 45616 15063
50	5505 9315 21908
	36046 32914 11836
	7304 39782 33721
	16905 29962 12980
55	11171 23709 22460
	34541 9937 44500
	14035 47316 8815
	15057 45482 24461

(continued)

Address of Parity Bit Accumulators (Rate 1/4)

30518 36877 879
 7583 13364 24332
 448 27056 4682
 12083 31378 21670
 1159 18031 2221
 17028 38715 9350
 17343 24530 29574
 46128 31039 32818
 20373 36967 18345
 46685 20622 32806

Address of Parity Bit Accumulators (Rate 2/5)

5650 4143 8750 583 6720 8071 635 1767 1344 6922 738 6658
 5696 1685 3207 415 7019 5023 5608 2605 857 6915 1770 8016
 3992 771 2190 7258 8970 7792 1802 1866 6137 8841 886 1931
 4108 3781 7577 6810 9322 8226 5396 5867 4428 8827 7766 2254
 4247 888 4367 8821 9660 324 5864 4774 227 7889 6405 8963
 9693 500 2520 2227 1811 9330 1928 5140 4030 4824 806 3134
 1652 8171 1435
 3366 6543 3745
 9286 8509 4645
 7397 5790 8972
 6597 4422 1799
 9276 4041 3847
 8683 7378 4946
 5348 1993 9186
 6724 9015 5646
 4502 4439 8474
 5107 7342 9442
 1387 8910 2660

11. A transmitter (200) according to claim 10, further comprising:

a modulator (205) configured to modulate the LDPC coded signal.

12. A transmitter (200) according to claim 11, wherein the modulated signal is transmitted over a satellite link (103) in support of a broadband satellite application.

13. A transmitter (200) according to claim 11, wherein the modulation is performed according to a signal constellation that includes one of 8-PSK, 16-QAM, QPSK, 16-APSK or 32-APSK, whereby PSK denotes Phase Shift keying, QAM denotes Quadrature Amplitude Modulation, QPSK denotes Quadrature Phase Shift keying and APSK denotes Amplitude Phase Shift keying.

Patentansprüche

1. Ein Verfahren zum Codieren, aufweisend:

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Empfangen von Informationsbits; und

auf der Grundlage der Informationsbits, Erzeugen von Paritätsbits von einem Low Density Parity Check (LD-PC)-Code gemäß einer Coderate von 1/3 oder einer Coderate von 1/4 oder einer Coderate von 2/5, indem Bits an Paritätsbit-Adressen, die durch die entsprechenden nachfolgenden Tabellen angegeben sind, unter Verwendung von Paritätsbit-Sammlern gesammelt werden,

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Adresse der Paritätsbit-Sammler (Rate 1/3)												
34903	20927	32093	1052	25611	16093	16454	5520	506	37399	18518	21120	
11636	14594	22158	14763	15333	6838	22222	37856	14985	31041	18704	32910	
17449	1665	35639	16624	12867	12449	10241	11650	25622	34372	19878	26894	
29235	19780	36056	20129	20029	5457	8157	35554	21237	7943	13873	14980	
9912	7143	35911	12043	17360	37253	25588	11827	29152	21936	24125	40870	
40701	36035	39556	12366	19946	29072	16365	35495	22686	11106	8756	34863	
19165	15702	13536	40238	4465	40034	40590	37540	17162	1712	20577	14138	
31338	19342	9301	39375	3211	1316	33409	28670	12282	6118	29236	35787	
11504	30506	19558	5100	24188	24738	30397	33775	9699	6215	3397	37451	
34689	23126	7571	1058	12127	27518	23064	11265	14867	30451	28289	2966	
11660	15334	16867	15160	38343	3778	4265	39139	17293	26229	42604	13486	
31497	1365	14828	7453	26350	41346	28643	23421	8354	16255	11055	24279	
15687	12467	13906	5215	41328	23755	20800	6447	7970	2803	33262	39843	
5363	22469	38091	28457	36696	34471	23619	2404	24229	41754	1297	18563	
3673	39070	14480	30279	37483	7580	29519	30519	39831	20252	18132	20010	
34386	7252	27526	12950	6875	43020	31566	39069	18985	15541	40020	16715	
1721	37332	39953	17430	32134	29162	10490	12971	28581	29331	6489	35383	
736	7022	42349	8783	6767	11871	21675	10325	11548	25978	431	24085	
1925	10602	28585	12170	15156	34404	8351	13273	20208	5800	15367	21764	
16279	37832	34792	21250	34192	7406	41488	18346	29227	26127	25493	7048	
39948	28229	24899										
17408	14274	38993										
38774	15968	28459										
41404	27249	27425										
41229	6082	43114										
13957	4979	40654										
3093	3438	34992										
34082	6172	28760										
42210	34141	41021										
14705	17783	10134										
41755	39884	22773										
14615	15593	1642										
29111	37061	39860										
9579	33552	633										
12951	21137	39608										
38244	27361	29417										
2939	10172	36479										
29094	5357	19224										
9562	24436	28637										
40177	2326	13504										
6834	21583	42516										
40651	42810	25709										
31557	32138	38142										
18624	41867	39296										
37560	14295	16245										

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(fortgesetzt)

Adresse der Paritätsbit-Sammler (Rate 1/3)	
5	6821 21679 31570
	25339 25083 22081
	8047 697 35268
	9884 17073 19995
	26848 35245 8390
10	18658 16134 14807
	12201 32944 5035
	25236 1216 38986
	42994 24782 8681
	28321 4932 34249
15	4107 29382 32124
	22157 2624 14468
	38788 27081 7936
	4368 26148 10578
20	25353 4122 39751

Adresse der Paritätsbit-Sammler (Rate 1/4)	
25	23606 36098 1140 28859 18148 18510 6226 540 42014 20879 23802 47088
	16419 24928 16609 17248 7693 24997 42587 16858 34921 21042 37024 20692
	1874 40094 18704 14474 14004 11519 13106 28826 38669 22363 30255 31105
	22254 40564 22645 22532 6134 9176 39998 23892 8937 15608 16854 31009
	8037 40401 13550 19526 41902 28782 13304 32796 24679 27140 45980 10021
30	40540 44498 13911 22435 32701 18405 39929 25521 12497 9851 39223 34823
	15233 45333 5041 44979 45710 42150 19416 1892 23121 15860 8832 10308
	10468 44296 3611 1480 37581 32254 13817 6883 32892 40258 46538 11940
	6705 21634 28150 43757 895 6547 20970 28914 30117 25736 41734 11392
35	22002 5739 27210 27828 34192 37992 10915 6998 3824 42130 4494 35739
	8515 1191 13642 30950 25943 12673 16726 34261 31828 3340 8747 39225
	18979 17058 43130 4246 4793 44030 19454 29511 47929 15174 24333 19354
	16694 8381 29642 46516 32224 26344 9405 18292 12437 27316 35466 41992
40	15642 5871 46489 26723 23396 7257 8974 3156 37420 44823 35423 13541
	42858 32008 41282 38773 26570 2702 27260 46974 1469 20887 27426 38553
	22152 24261 8297
	19347 9978 27802
	34991 6354 33561
45	29782 30875 29523
	9278 48512 14349
	38061 4165 43878
	8548 33172 34410
	22535 28811 23950
50	20439 4027 24186
	38618 8187 30947
	35538 43880 21459
	7091 45616 15063
55	5505 9315 21908
	36046 32914 11836
	7304 39782 33721
	16905 29962 12980

(fortgesetzt)

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Adresse der Paritätsbit-Sammler (Rate 1/4)		
11171	23709	22460
34541	9937	44500
14035	47316	8815
15057	45482	24461
30518	36877	879
7583	13364	24332
448	27056	4682
12083	31378	21670
1159	18031	2221
17028	38715	9350
17343	24530	29574
46128	31039	32818
20373	36967	18345
46685	20622	32806

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Adresse der Paritätsbit-Sammler (Rate 2/5)		
5650	4143	8750
5696	1685	3207
3992	771	2190
4108	3781	7577
4247	888	4367
9693	500	2520
1652	8171	1435
3366	6543	3745
9286	8509	4645
7397	5790	8972
6597	4422	1799
9276	4041	3847
8683	7378	4946
5348	1993	9186
6724	9015	5646
4502	4439	8474
5107	7342	9442
1387	8910	2660

2. Ein Verfahren nach Anspruch 1, des Weiteren aufweisend:

Modulieren des LDPC-codierten Signals; und
Übertragen des modulierten Signals.

3. Ein Verfahren nach dem Anspruch 2, wobei das modulierte Signal über eine Satellitenverbindung (103) übertragen wird, um eine breitbandige Satellitenanwendung zu unterstützen.

4. Ein Verfahren nach Anspruch 2, wobei der Schritt des Modulierens gemäß einer Signalkonstellation ausgeführt wird, die ein Element aus der Gruppe bestehend aus 8-PSK, 16-QAM, QPSK, 16-APSK oder 32-APSK aufweist, wobei PSK für Phasenmodulation (Phase Shift Keying) steht, QAM für Quadraturamplitudenmodulation (Quadrature Amplitude Modulation) steht, QPSK für Quadraturphasenmodulation (Quadrature Phase Shift Keying) steht und APSK für Amplitudenphasenmodulation (Amplitude Phase Shift Keying) steht.

5. Ein computerlesbares Medium, das Anweisungen zur Codierung enthält, wobei die Anweisungen so angeordnet sind, dass bei der Ausführung ein oder mehrere Prozessoren veranlasst werden, das Verfahren nach Anspruch 1 auszuführen.

- 5 6. Ein Codierer (203) aufweisend:

Mittel zum Empfangen von Informationsbits; und

10 Mittel zum Generieren, auf der Grundlage der Informationsbits, eines Low Density Parity Check (LDPC)-Codes gemäß einer aus einer Mehrzahl von Coderaten, indem Bits an Paritätsbit-Adressen, die durch die entsprechenden nachfolgenden Tabellen angegeben sind, unter Verwendung von Paritätsbit-Sammlern gesammelt werden,

Adresse der Paritätsbit-Samler (Rate 1/3)	
15	34903 20927 32093 1052 25611 16093 16454 5520 506 37399 18518 21120 11636 14594 22158 14763 15333 6838 22222 37856 14985 31041 18704 32910 17449 1665 35639 16624 12867 12449 10241 11650 25622 34372 19878 26894 29235 19780 36056 20129 20029 5457 8157 35554 21237 7943 13873 14980 9912 7143 35911 12043 17360 37253 25588 11827 29152 21936 24125 40870
20	40701 36035 39556 12366 19946 29072 16365 35495 22686 11106 8756 34863 19165 15702 13536 40238 4465 40034 40590 37540 17162 1712 20577 14138 31338 19342 9301 39375 3211 1316 33409 28670 12282 6118 29236 35787 11504 30506 19558 5100 24188 24738 30397 33775 9699 6215 3397 37451
25	34689 23126 7571 1058 12127 27518 23064 11265 14867 30451 28289 2966 11660 15334 16867 15160 38343 3778 4265 39139 17293 26229 42604 13486 31497 1365 14828 7453 26350 41346 28643 23421 8354 16255 11055 24279 15687 12467 13906 5215 41328 23755 20800 6447 7970 2803 33262 39843 5363 22469 38091 28457 36696 34471 23619 2404 24229 41754 1297 18563
30	3673 39070 14480 30279 37483 7580 29519 30519 39831 20252 18132 20010 34386 7252 27526 12950 6875 43020 31566 39069 18985 15541 40020 16715 1721 37332 39953 17430 32134 29162 10490 12971 28581 29331 6489 35383 736 7022 42349 8783 6767 11871 21675 10325 11548 25978 431 24085
35	1925 10602 28585 12170 15156 34404 8351 13273 20208 5800 15367 21764 16279 37832 34792 21250 34192 7406 41488 18346 29227 26127 25493 7048 39948 28229 24899 17408 14274 38993 38774 15968 28459
40	41404 27249 27425 41229 6082 43114 13957 4979 40654 3093 3438 34992 34082 6172 28760
45	42210 34141 41021 14705 17783 10134 41755 39884 22773 14615 15593 1642
50	29111 37061 39860 9579 33552 633 12951 21137 39608 38244 27361 29417
55	2939 10172 36479 29094 5357 19224 9562 24436 28637 40177 2326 13504

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(fortgesetzt)

Adresse der Paritätsbit-Samler (Rate 1/3)	
5	6834 21583 42516 40651 42810 25709 31557 32138 38142 18624 41867 39296 37560 14295 16245
10	6821 21679 31570 25339 25083 22081 8047 697 35268 9884 17073 19995 26848 35245 8390
15	18658 16134 14807 12201 32944 5035 25236 1216 38986 42994 24782 8681
20	28321 4932 34249 4107 29382 32124 22157 2624 14468 38788 27081 7936 4368 26148 10578
25	25353 4122 39751

Adresse der Paritätsbit-Summler (Rate 1/4)	
30	23606 36098 1140 28859 18148 18510 6226 540 42014 20879 23802 47088 16419 24928 16609 17248 7693 24997 42587 16858 34921 21042 37024 20692 1874 40094 18704 14474 14004 11519 13106 28826 38669 22363 30255 31105 22254 40564 22645 22532 6134 9176 39998 23892 8937 15608 16854 31009
35	8037 40401 13550 19526 41902 28782 13304 32796 24679 27140 45980 10021 40540 44498 13911 22435 32701 18405 39929 25521 12497 9851 39223 34823 15233 45333 5041 44979 45710 42150 19416 1892 23121 15860 8832 10308 10468 44296 3611 1480 37581 32254 13817 6883 32892 40258 46538 11940
40	6705 21634 28150 43757 895 6547 20970 28914 30117 25736 41734 11392 22002 5739 27210 27828 34192 37992 10915 6998 3824 42130 4494 35739 8515 1191 13642 30950 25943 12673 16726 34261 31828 3340 8747 39225 18979 17058 43130 4246 4793 44030 19454 29511 47929 15174 24333 19354
45	16694 8381 29642 46516 32224 26344 9405 18292 12437 27316 35466 41992 15642 5871 46489 26723 23396 7257 8974 3156 37420 44823 35423 13541 42858 32008 41282 38773 26570 2702 27260 46974 1469 20887 27426 38553 22152 24261 8297 19347 9978 27802 34991 6354 33561
50	29782 30875 29523 9278 48512 14349 38061 4165 43878 8548 33172 34410 22535 28811 23950
55	20439 4027 24186 38618 8187 30947 35538 43880 21459

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Adresse der Paritätsbit-Summler (Rate 1/4)		
7091	45616	15063
5505	9315	21908
36046	32914	11836
7304	39782	33721
16905	29962	12980
11171	23709	22460
34541	9937	44500
14035	47316	8815
15057	45482	24461
30518	36877	879
7583	13364	24332
448	27056	4682
12083	31378	21670
1159	18031	2221
17028	38715	9350
17343	24530	29574
46128	31039	32818
20373	36967	18345
46685	20622	32806

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Adresse der Paritätsbit-Sammler (Rate 2/5)		
5650	4143	8750 583 6720 8071 635 1767 1344 6922 738 6658
5696	1685	3207 415 7019 5023 5608 2605 857 6915 1770 8016
3992	771	2190 7258 8970 7792 1802 1866 6137 8841 886 1931
4108	3781	7577 6810 9322 8226 5396 5867 4428 8827 7766 2254
4247	888	4367 8821 9660 324 5864 4774 227 7889 6405 8963
9693	500	2520 2227 1811 9330 1928 5140 4030 4824 806 3134
1652	8171	1435
3366	6543	3745
9286	8509	4645
7397	5790	8972
6597	4422	1799
9276	4041	3847
8683	7378	4946
5348	1993	9186
6724	9015	5646
4502	4439	8474
5107	7342	9442
1387	8910	2660

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; und

Mittel zum Generieren eines äußeren Bose Chaudhuri Hocquenghem (BCH) Codes für den LDPC-Code.

7. Ein Codierer (203) nach Anspruch 6, wobei das LDPC-codierte Signal moduliert und übertragen wird.
8. Ein Codierer (203) nach Anspruch 7, wobei das modulierte Signal eine breitbandige Satellitenanwendung unterstützt.
9. Ein Codierer (203) nach Anspruch 7, wobei die Modulation gemäß einer Signalkonstellation ausgeführt wird, die

ein Element aus der Gruppe bestehend aus 8-PSK, 16-QAM, QPSK, 16-APSK oder 32-APSK aufweist, wobei PSK für Phasenmodulation (Phase Shift Keying) steht, QAM für Quadraturamplitudenmodulation (Quadrature Amplitude Modulation) steht, QPSK für Quadraturphasenmodulation (Quadrature Phase Shift Keying) steht und APSK für Amplitudenphasenmodulation (Amplitude Phase Shift Keying) steht.

10. Ein Sender (200) für eine Unterstützung einer Übertragung eines Low Density Parity Check (LDPC)-codierten Signals, aufweisend:

einen Low Density Parity Check (LDPC)-Codierer (203), der dafür ausgebildet ist, auf der Grundlage von empfangenen Informationsbits einen LDPC-Code auszugeben; und
einen Bose Chaudhuri Hocquenghem (BCH)-Codierer (211), der mit dem LDPC-Codierer (203) verbunden ist und dafür ausgebildet ist, einen äußeren Code für den LDPC-Code bereitzustellen, wobei der LDPC-Code generiert wird gemäß einer Coderate von 1/3 oder einer Coderate von 1/4 oder einer Coderate von 2/5, indem Bits an Paritätsbit-Adressen, die durch die entsprechenden nachfolgenden Tabellen angegeben sind, unter Verwendung von Paritätsbit-Sammlern gesammelt werden,

Adresse der Paritätsbit-Sammler (Rate 1/3)

34903 20927 32093 1052 25611 16093 16454 5520 506 37399 18518 21120
11636 14594 22158 14763 15333 6838 22222 37856 14985 31041 18704 32910
17449 1665 35639 16624 12867 12449 10241 11650 25622 34372 19878 26894
29235 19780 36056 20129 20029 5457 8157 35554 21237 7943 13873 14980
9912 7143 35911 12043 17360 37253 25588 11827 29152 21936 24125 40870
40701 36035 39556 12366 19946 29072 16365 35495 22686 11106 8756 34863
19165 15702 13536 40238 4465 40034 40590 37540 17162 1712 20577 14138
31338 19342 9301 39375 3211 1316 33409 28670 12282 6118 29236 35787
11504 30506 19558 5100 24188 24738 30397 33775 9699 6215 3397 37451
34689 23126 7571 1058 12127 27518 23064 11265 14867 30451 28289 2966
11660 15334 16867 15160 38343 3778 4265 39139 17293 26229 42604 13486
31497 1365 14828 7453 26350 41346 28643 23421 8354 16255 11055 24279
15687 12467 13906 5215 41328 23755 20800 6447 7970 2803 33262 39843
5363 22469 38091 28457 36696 34471 23619 2404 24229 41754 1297 18563
3673 39070 14480 30279 37483 7580 29519 30519 39831 20252 18132 20010
34386 7252 27526 12950 6875 43020 31566 39069 18985 15541 40020 16715
1721 37332 39953 17430 32134 29162 10490 12971 28581 29331 6489 35383
736 7022 42349 8783 6767 11871 21675 10325 11548 25978 431 24085
1925 10602 28585 12170 15156 34404 8351 13273 20208 5800 15367 21764
16279 37832 34792 21250 34192 7406 41488 18346 29227 26127 25493 7048
39948 28229 24899
17408 14274 38993
38774 15968 28459
41404 27249 27425
41229 6082 43114
13957 4979 40654
3093 3438 34992
34082 6172 28760
42210 34141 41021
14705 17783 10134
41755 39884 22773
14615 15593 1642
29111 37061 39860
9579 33552 633
12951 21137 39608
38244 27361 29417

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Adresse der Paritätsbit-Sammler (Rate 1/3)	
5	2939 10172 36479
	29094 5357 19224
	9562 24436 28637
	40177 2326 13504
	6834 21583 42516
10	40651 42810 25709
	31557 32138 38142
	18624 41867 39296
	37560 14295 16245
	6821 21679 31570
15	25339 25083 22081
	8047 697 35268
	9884 17073 19995
	26848 35245 8390
20	18658 16134 14807
	12201 32944 5035
	25236 1216 38986
	42994 24782 8681
	28321 4932 34249
25	4107 29382 32124
	22157 2624 14468
	38788 27081 7936
	4368 26148 10578
30	25353 4122 39751

Adresse der Paritätsbit-Sammder (Rate 1/4)	
35	23606 36098 1140 28859 18148 18510 6226 540 42014 20879 23802 47088
	16419 24928 16609 17248 7693 24997 42587 16858 34921 21042 37024 20692
	1874 40094 18704 14474 14004 11519 13106 28826 38669 22363 30255 31105
	22254 40564 22645 22532 6134 9176 39998 23892 8937 15608 16854 31009
	8037 40401 13550 19526 41902 28782 13304 32796 24679 27140 45980 10021
40	40540 44498 13911 22435 32701 18405 39929 25521 12497 9851 39223 34823
	15233 45333 5041 44979 45710 42150 19416 1892 23121 15860 8832 10308
	10468 44296 3611 1480 37581 32254 13817 6883 32892 40258 46538 11940
	6705 21634 28150 43757 895 6547 20970 28914 30117 25736 41734 11392
45	22002 5739 27210 27828 34192 37992 10915 6998 3824 42130 4494 35739
	8515 1191 13642 30950 25943 12673 16726 34261 31828 3340 8747 39225
	18979 17058 43130 4246 4793 44030 19454 29511 47929 15174 24333 19354
	16694 8381 29642 46516 32224 26344 9405 18292 12437 27316 35466 41992
	15642 5871 46489 26723 23396 7257 8974 3156 37420 44823 35423 13541
50	42858 32008 41282 38773 26570 2702 27260 46974 1469 20887 27426 38553
	22152 24261 8297
	19347 9978 27802
	34991 6354 33561
55	29782 30875 29523
	9278 48512 14349
	38061 4165 43878
	8548 33172 34410

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Adresse der Paritätsbit-Sammder (Rate 1/4)		
22535 28811 23950		
20439 4027 24186		
38618 8187 30947		
35538 43880 21459		
7091 45616 15063		
5505 9315 21908		
36046 32914 11836		
7304 39782 33721		
16905 29962 12980		
11171 23709 22460		
34541 9937 44500		
14035 47316 8815		
15057 45482 24461		
30518 36877 879		
7583 13364 24332		
448 27056 4682		
12083 31378 21670		
1159 18031 2221		
17028 38715 9350		
17343 24530 29574		
46128 31039 32818		
20373 36967 18345		
46685 20622 32806		

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Adresse der Paritätsbit-Sammler (Rate 2/5)		
5650 4143 8750 583 6720 8071 635 1767 1344 6922 738 6658		
5696 1685 3207 415 7019 5023 5608 2605 857 6915 1770 8016		
3992 771 2190 7258 8970 7792 1802 1866 6137 8841 886 1931		
4108 3781 7577 6810 9322 8226 5396 5867 4428 8827 7766 2254		
4247 888 4367 8821 9660 324 5864 4774 227 7889 6405 8963		
9693 500 2520 2227 1811 9330 1928 5140 4030 4824 806 3134		
1652 8171 1435		
3366 6543 3745		
9286 8509 4645		
7397 5790 8972		
6597 4422 1799		
9276 4041 3847		
8683 7378 4946		
5348 1993 9186		
6724 9015 5646		
4502 4439 8474		
5107 7342 9442		
1387 8910 2660		

11. Ein Sender (200) nach Anspruch 10, des Weiteren aufweisend:

einen Modulator (205), der dafür ausgebildet ist, das LDPC-codierte Signal zu modulieren.

12. Ein Sender (200) nach Anspruch 11, wobei das modulierte Signal über eine Satellitenverbindung (103) übertragen wird, um eine breitbandige Satellitenanwendung zu unterstützen.

13. Ein Sender (200) nach Anspruch 11, wobei die Modulation gemäß einer Signalkonstellation ausgeführt wird, die ein Element aus der Gruppe bestehend aus 8-PSK, 16-QAM, QPSK, 16-APSK oder 32-APSK aufweist, wobei PSK für Phasenmodulation (Phase Shift Keying) steht, QAM für Quadraturamplitudenmodulation (Quadrature Amplitude Modulation) steht, QPSK für Quadraturphasenmodulation (Quadrature Phase Shift Keying) steht und APSK für Amplitudenphasenmodulation (Amplitude Phase Shift Keying) steht.

Revendications

1. Procédé de codage, comprenant les étapes suivantes :

recevoir des bits d'information ; et
produire, sur la base de ces bits d'information, des bits de parité d'un code LDPC (pour « *Low Density Parity Check* » - Contrôle de parité à faible densité), avec un débit de code de 1/3, de 1/4 ou de 2/5, en accumulant des bits à des adresses de bits de parité spécifiées par les tables suivantes, respectivement, en utilisant des accumulateurs de bits de parité.

Adresses des accumulateurs de bits de parité (débit 1/3)

34903 20927 32093 1052 25611 16093 16454 5520 506 37399 18518 21120
11636 14594 22158 14763 15333 6838 22222 37856 14985 31041 18704 32910
17449 1665 35639 16624 12867 12449 10241 11650 25622 34372 19878 26894
29235 19780 36056 20129 20029 5457 8157 35554 21237 7943 13873 14980
9912 7143 35911 12043 17360 37253 25588 11827 29152 21936 24125 40870
40701 36035 39556 12366 19946 29072 16365 35495 22686 11106 8756 34863
19165 15702 13536 40238 4465 40034 40590 37540 17162 1712 20577 14138
31338 19342 9301 39375 3211 1316 33409 28670 12282 6118 29236 35787
11504 30506 19558 5100 24188 24738 30397 33775 9699 6215 3397 37451
34689 23126 7571 1058 12127 27518 23064 11265 14867 30451 28289 2966
11660 15334 16867 15160 38343 3778 4265 3913917293 26229 42604 13486
31497 1365 14828 7453 26350 41346 28643 23421 8354 16255 11055 24279
15687 12467 13906 5215 41328 23755 20800 6447 7970 2803 33262 39843
5363 22469 38091 28457 36696 34471 23619 2404 24229 41754 1297 18563
3673 39070 14480 30279 37483 7580 29519 30519 39831 20252 18132 20910
34386 7252 27526 12950 6875 43020 31566 39069 18985 15541 40020 16715
1721 37332 39953 17430 32134 29162 10490 12971 28581 29331 6489 35383
736 7022 42349 8783 6767 11871 21675 10325 11548 25978 431 24085
1925 10602 28585 12170 15156 34404 8351 13273 20208 5800 15367 21764
16279 37832 34792 21250 34192 7406 41488 18346 29227 26127 25493 7048
39948 28229 24899
17408 14274 38993
38774 15968 28459
41404 27249 27425
41229 6082 43114
13957 4979 40654
3093 3438 34992
34082 6172 28760
42210 34141 41021
14705 17783 10134
41755 39884 22773
14615 15593 1642

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Adresses des accumulateurs de bits de parité (débit 1/3)

29111 37061 39860
 9579 33552 633
 12951 21137 39608
 38244 27361 29417
 2939 10172 36479
 29094 5357 19224
 9562 24436 28637
 40177 2326 13504
 6834 21583 42516
 46651 42810 25709
 31557 32138 38142
 18624 41867 39296
 37560 14295 16245
 6821 21679 31570
 25339 25083 22081
 8047 697 35268
 9894 17073 19995
 26848 35245 8390
 18658 16134 14807
 12201 32944 5035
 25236 1216 38986
 42994 24782 8681
 28321 4932 34249
 4107 29382 32124
 22157 2624 14468
 38788 27081 7936
 4368 26148 10578
 25353 4122 39751

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Adresses des accumulateurs de bits de parité (débit 1/4)

23606 36098 1140 28859 18148 18510 6226 540 42014 20879 23802 47088
 16419 24928 16609 17248 7693 24997 42587 16858 34921 21042 37024 20692
 1874 40094 18704 14474 14004 11519 13106 28826 38669 22363 30255 31105
 22234 40564 22645 22532 6134 9176 39998 23892 8937 15608 16854 31009
 8037 40401 13550 19526 41902 28782 13304 32796 24679 27140 45980 10021
 40540 44498 13911 22435 32701 18405 39929 25521 12497 985139223 34823
 15233 45333 5041 44979 45 110 42150 19416 1892 23121 15864 9832 10308
 10468 44296 3611 1480 37581 32254 13817 6883 32892 40258 46538 11940
 6705 21634 28150 43757 895 6547 20970 28914 30117 25736 41734 11392
 22002 5739 27210 27828 34192 37992 10915 6998 3824 42130 4494 35739
 8515 1191 13642 30950 25943 12673 16726 34261 31828 3340 8747 39225
 18979 17058 43130 4246 4793 44030 19454 29511 47929 15174 24333 19354
 16694 8381 29642 46516 32224 26344 9405 18292 12437 27316 35466 41992
 15642 5871 46489 26723 23396 7257 8974 3156 37420 44823 35423 13541
 42858 32008 41282 38773 26570 2702 27260 46974 1469 20887 27426 38553
 22152 24261 8297
 19347 9978 27802
 34991 6354 33561

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Adresses des accumulateurs de bits de parité (débit 1/4)

29782 30875 29523
 9278 48512 14349
 38061 4165 43878
 8548 33172 34410
 22535 28811 23950
 20439 4027 24186
 38618 8187 30947
 35538 43880 21459
 7091 45616 15063
 5505 9315 21908
 36046 32914 11836
 7304 39782 33721
 16905 29962 12980
 11171 23709 22460
 34541 9937 44540
 14035 47316 8815
 15057 45482 24461
 30518 36877 879
 7583 13364 24332
 448 27056 4682
 12083 31378 21670
 1159 18031 2221
 17028 38715 9350
 17343 24530 29574
 46128 31039 32818
 20373 36967 18345
 46685 20622 32806

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Adresses des accumulateurs de bits de parité (débit 2/5)

5650 4143 8750 583 6720 8071 635 1767 1344 6922 738 6658
 5696 1685 3207 415 7019 5023 5608 2605 857 6915 1770 8016
 3992 771 2190 7258 8970 7792 1802 1866 6137 8841 886 1931
 4108 3781 7577 6810 9322 8226 5396 5867 4428 8827 7766 2254
 4247 888 4367 8821 9660 324 5864 4774 227 7889 6405 8963
 9693 500 2520 2227 1811 9330 1928 5140 4030 4824 806 3134
 1652 8171 1435
 3366 6543 3745
 9286 8509 4645
 7397 5790 8972
 6597 4422 1799
 9276 4041 3847
 8683 7378 4946
 5348 1993 9186
 6724 9015 5646
 4502 4439 8474
 5107 7342 9442
 1387 8910 2660

2. Procédé selon la revendication 1, comprenant en outre les étapes consistant à :

moduler le signal codé LDPC ; et
émettre le signal modulé.

3. Procédé selon la revendication 2, dans lequel le signal modulé est transmis sur une liaison par satellite (103) pour supporter une application satellitaire à large bande.

4. Procédé selon la revendication 2, dans lequel l'étape de modulation est exécutée selon une constellation de signal comprenant l'un des modes de modulation suivants : 8-PSK (pour « *Phase Shift Keying* » - Modulation à déplacement de phase), 16-QAM (pour « *Quadrature Amplitude Modulation* » - Modulation d'amplitude en quadrature), QPSK (pour « *Quadrature Phase Shift Keying* » - Modulation par quadrature de phase), 16-APSK (pour « *Amplitude Phase Shift Keying* » - Modulation à déplacement d'amplitude et de phase) ou 32-APSK.

5. Support lisible par ordinateur portant des instructions pour le codage, lesdites instructions étant agencées, lors de l'exécution, pour amener un ou plusieurs processeurs à exécuter le procédé de la revendication 1.

6. Codeur (203) comprenant :

un moyen destiné à recevoir des bits d'information ; et
un moyen destiné à produire, sur la base de ces bits d'information, des bits de parité d'un code LDPC selon une pluralité de débits de code, en accumulant des bits à des adresses de bits de parité spécifiées par les tables suivantes, respectivement, en utilisant des accumulateurs de bits de parité

Adresses des accumulateurs de bits de parité (débit 1/3)

34903	20927	32093	1052	25611	16093	16454	5520	506	37399	18518	21120
11636	14594	22158	14763	15333	6838	22222	37856	14985	31041	18704	32910
17449	1665	35639	16624	12867	12449	10241	11650	25622	34372	19878	26894
29235	19780	36056	20129	20029	5457	8157	35554	21237	7943	13873	14980
9912	7143	35911	12043	17360	37253	25588	11827	29152	21936	24125	40870
40701	36035	39556	12366	19946	29072	16365	35495	22686	11106	8756	34863
19165	15702	13536	40238	4465	40034	40590	37540	17162	1712	20577	14138
31338	19342	9301	39375	3211	1316	33409	28670	12282	6118	29236	35787
11504	30506	19558	5100	24188	24738	30397	33775	9699	6215	3397	37451
34689	23126	7571	1058	12127	27518	23064	11265	14867	30451	28289	2966
11660	15334	16867	15160	38343	3778	4265	39139	17293	26229	42604	13486
31497	1365	14828	7453	26350	41346	28643	23421	8354	16255	11055	24279
15687	12467	13906	5215	41328	23755	20800	6447	7970	2803	33262	39843
5363	22469	38091	28457	36696	34471	23619	2404	24229	41754	1297	18563
3673	39070	14480	30279	37483	7580	29519	30519	39831	20252	18132	20010
34386	7252	27526	12950	6875	43020	31566	39069	18985	15541	40020	16715
1721	37332	39953	17430	32134	29162	10490	12971	28581	29331	6489	35383
736	7022	42349	8783	6767	11871	21675	10325	11548	25978	431	24085
1925	10602	28585	12170	15156	34404	8351	13273	20208	5800	15367	11764
16279	37832	34792	21250	34192	7406	41488	18346	29227	26127	25493	7048
39948	28229	24899									
17408	14274	38993									
38774	15968	28459									
41404	27249	27425									
41229	6082	43114									
13957	4979	40654									
3093	3438	34992									
34082	6172	28760									
42210	34141	41021									

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Adresses des accumulateurs de bits de parité (débit 1/3)

14705 17783 10134
 41755 39894 22773
 14615 15593 1642
 29111 37061 39860
 9579 33552 633
 12951 21137 39608
 38244 27361 29417
 2939 10172 36479
 29094 5357 19224
 9562 24436 28637
 40177 2326 13504
 6834 21583 42516
 40651 42810 25709
 31557 32138 38142
 18624 41867 39296
 37560 14295 16245
 6821 21679 31570
 25339 25083 22081
 8047 697 35268
 9884 17073 19995
 26848 35245 8390
 18658 16134 14807
 12201 32944 5035
 25236 1216 38986
 42994 24782 8681
 28321 4932 34249
 4107 29382 37124
 22157 2624 14468
 38788 27081 7936
 4368 26148 10578
 25353 4122 39751

Adresses des accumulateurs de bits de parité (débit 1/4)

23606 36098 1140 28859 18148 18510 6226 540 42014 20879 23802 47088
 16419 24928 16609 17248 7693 24997 42S87 16858 34921 21042 37024 20692
 1874 40094 18704 14474 14004 11519 13106 28826 38669 22363 30255 31105
 22254 40554 22645 22532 6134 9176 39998 23892 8937 15608 16854 31009
 8037 40401 13550 19526 41902 28782 13304 32796 24679 27140 45980 10021
 40540 44498 13911 22435 32701 18405 39929 25521 12497 9851 39223 34923
 15233 45333 5041 44979 45710 42150 19416 1892 23121 15860 8832 10308
 10468 44296 3611 1480 37581 32254 13817 6883 32892 40258 46538 11940
 6705 21634 28150 43757 895 6547 20970 28914 30117 23736 41734 11392
 22002 5739 27210 27828 34192 37992 10915 6998 3824 42130 4494 35739
 8515 1191 13642 30950 25943 12673 16726 34261 31828 3340 8747 39225
 18979 17058 43130 4246 4793 44030 19454 29511 47929 15174 24333 19354
 16694 8381 29642 46516 32224 26344 9405 18292 12437 27316 35466 41992
 15642 5871 46489 26723 23396 7257 8974 3156 37420 44823 35423 13541
 42858 32008 41282 38773 26510 2702 27260 46974 1469 20887 27426 38553

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Adresses des accumulateurs de bits de parité (débit 1/4)	
5	22152 24261 8297 19347 9978 27802 34991 6354 33561 29782 30875 29523 9278 48512 14349
10	38061 4165 43878 8548 33172 34410 22535 28811 23950 20439 4027 24186 38618 8187 30947
15	35538 43880 21459 7091 45616 15063 5505 9315 21908 36046 32914 11836 7304 39782 33721
20	16905 29962 12980 11171 23709 22460 34541 9937 44500 14035 47316 8815 15057 45482 24461
25	30518 36877 879 7583 13364 24332 448 27056 4682 12083 31378 21670 1159 18031 2221
30	17028 38715 9350 17343 24530 29574 46128 31039 32818 20373 36967 18345 46685 20622 32806

Adresses des accumulateurs de bits de parité (débit 2/5)	
40	5650 4143 8750 583 6720 8071 635 1767 1344 6922 738 6658 5696 1685 3207 415 7019 5023 5608 2605 857 6915 1770 8016 3992 771 2190 7258 8970 7792 1802 1866 6137 8841 886 1931
45	4108 3781 7577 6810 9322 8226 5396 5867 4428 8827 7766 2254 4247 888 4367 8821 9660 324 5864 4774 227 7889 6405 8963 9693 500 2520 2227 1811 9330 1928 5140 4030 4824 806 3134 1652 8171 1435 3366 6543 3745
50	9286 8509 4645 7397 5790 8972 6597 4422 1799 9276 4041 3847 8683 7378 4946
55	5348 1993 9186 6724 9015 5646 4502 4439 8474

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(suite)

Adresses des accumulateurs de bits de parité (débit 2/5)
5107 7342 9442
1387 8910 2660

et

un moyen destiné à produire un code de Bose Chaudhuri Hocquenghem (BCH) extérieur pour le code LDPC.

7. Codeur (203) selon la revendication 6, dans lequel le signal codé LDPC est modulé et émis.
8. Codeur (203) selon la revendication 7, dans lequel le signal modulé est utilisé pour le support d'une application satellitaire à large bande.
9. Codeur (203) selon la revendication 7, dans lequel la modulation est exécutée selon une constellation de signal comprenant l'un des modes de modulation suivants : 8-PSK (pour « *Phase Shift Keying* »), 16-QAM (pour « *Quadrature Amplitude Modulation* »), QPSK (pour « *Quadrature Phase Shift Keying* »), 16-APSK (pour « *Amplitude Phase Shift Keying* ») et 32-APSK.
10. Émetteur (200) destiné à supporter l'émission d'un signal codé LDPC, comprenant :

un codeur LDPC (203), configuré pour fournir en sortie, sur la base de bits d'information reçus, un code LDPC ; et un codeur de Bose Chaudhuri Hocquenghem (BCH) (211) couplé au codeur LDPC (203) et configuré pour fournir un code extérieur au code LDPC, dans lequel le code LDPC est produit selon un débit de code de 1/3, de 1/4 ou de 2/5, en accumulant des bits à des adresses de bits de parité spécifiées par les tables suivantes, respectivement, en utilisant des accumulateurs de bits de parité

Adresses des accumulateurs de bits de parité (débit 1/3)
34903 20927 32093 1052 25611 16093 16454 5520 506 37399 18518 21320
11636 14594 22158 14763 15333 6838 22222 37856 14985 31041 18704 32910
17449 1665 35639 16624 12867 12449 10241 11650 25622 34372 19878 26894
29235 19780 36056 20129 20029 5457 8157 35554 21237 7943 13873 14980
9912 7143 35911 12043 17360 37253 25588 11827 29152 21936 24125 40870
40701 36035 39556 12366 19946 29072 16365 35495 22686 11106 8756 34863
19165 15702 13536 40238 4465 40034 44590 37540 17162 1712 20577 14138
31338 19342 9301 39375 3211 1316 33409 28670 12282 6118 29236 35787
11504 30506 19558 5100 24188 24738 30397 33775 9699 6215 3397 37451
34689 23126 7571 1058 12127 27518 23064 11265 14867 30451 28289 2966
11660 15334 16867 15160 38343 3778 4265 39139 17293 26229 42604 13486
31497 1365 14828 7453 26350 41346 28643 23421 9354 16255 11055 24279
15687 12467 13906 5215 41328 23755 20800 6447 7970 2803 33262 39843
5363 22469 38091 28437 36696 34471 23619 2404 24229 41754 1297 18563
3673 39070 14480 30279 37483 7580 29519 30519 39831 20252 18132 20010
34386 7252 27526 12950 6875 43020 31566 39069 18985 15541 40020 16715
1721 37332 39953 17430 32134 29162 10490 12971 28581 29331 6489 35383
736 7022 42349 8783 6767 11871 21675 10325 11548 25978 431 24085
1925 10602 28585 12170 15156 34404 8351 13273 20208 5800 15367 21764
16279 37832 34792 21250 34192 7406 41488 18346 29227 26127 25493 7048
39948 28229 24899
17408 14274 38993
38774 15968 28459
41404 27249 27425
41229 6082 43114
13957 4979 40654

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(suite)

Adresses des accumulateurs de bits de parité (débit 1/3)	
5	3093 3438 34992
	34082 6172 28760
	42210 34141 41021
	14705 17783 10134
	41755 39884 22773
10	14615 15593 1642
	29111 37061 39860
	9579 33552 633
	12951 21137 39608
15	38244 27361 29417
	2939 10172 36479
	29094 5357 19224
	9562 24436 28637
	40177 2326 13504
20	6834 21583 42516
	40651 42810 25709
	31557 32138 38142
	18624 41867 39296
	37560 14295 16245
25	6821 21679 31570
	25339 25083 22081
	8047 697 35268
	9884 17073 19995
30	26848 35245 8390
	18658 16134 14807
	12201 32944 5035
	25236 1216 38986
	42994 24782 8681
35	28321 4932 34249
	4107 29382 32124
	22157 2624 14468
	38788 27081 7936
40	4368 26148 10578
	25353 4122 39751

Adresses des accumulateurs de bits de parité (débit 1/4)	
45	23606 36098 1140 28859 18148 18510 6226 540 42014 20879 23802 47088
	16419 24928 16609 17248 7693 24997 42587 16858 34921 21042 37024 20692
	1874 40094 18704 14474 14004 11519 13106 28826 38669 22363 30255 31105
	22254 40564 22645 22532 6134 9176 39998 23892 8937 15608 16854 31009
50	8037 40401 13550 19526 41902 28782 13304 32796 24679 27140 45980 10021
	40540 44498 13911 22435 32701 18405 39929 25521 12497 9851 39223 34823
	15233 45333 5041 44979 45710 42150 19416 1892 23121 15860 8832 10308
	10468 44296 3611 1480 37581 32254 13817 6883 32892 40258 46538 11940
55	6705 21634 28150 43757 895 6547 20970 28914 30117 25736 41734 11392
	22002 5739 27210 27828 34192 37992 10915 6998 3824 42130 4494 35739
	8515 1191 13642 30950 25943 12673 16726 34261 31828 3340 8747 39225
	18979 17058 43130 4246 4793 44030 19454 29511 47929 15174 24333 19354

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(suite)

	Adresses des accumulateurs de bits de parité (débit 1/4)
5	16694 8381 29642 46516 32224 26344 9405 18292 12437 27316 35466 41992 15642 5871 46489 26723 23396 7257 8974 3156 37420 44823 35423 13541 42858 32008 41282 38773 26570 2702 27260 46974 1469 20887 27426 38553 22152 24261 8297 19347 9978 27802
10	34991 6354 33561 29782 30875 29523 9278 48512 14349 38061 4165 43878 8548 33172 34410
15	22535 28811 23950 20439 4027 24186 38618 8187 30947 35538 43880 21459
20	7091 45616 15063 5505 9315 21908 36046 32914 11836 7304 39782 33721 16905 29962 12980
25	11171 23709 22460 34541 9937 44500 14035 47316 8815 13057 45482 24461 30518 36877 879
30	7583 13364 24332 448 27056 4682 12083 31378 21670 1159 18031 2221
35	17028 38715 9350 17343 24530 29574 46128 31039 32818 20373 36967 18345 46685 20622 32806
40	

	Adresses des accumulateurs de bits de parité (débit 2/5)
45	5650 4143 8750 583 6720 8071 635 1767 1344 6922 738 6658 5696 1685 3207 415 7019 5023 5608 2605 857 6915 1770 8016 3992 771 2190 7258 8970 7792 1802 1866 6137 8841 886 1931 4108 3781 7577 6810 9322 8226 5396 5867 4428 8827 7766 2254
50	4247 888 4367 8821 9660 324 5864 4774 227 7889 6405 8963 9693 500 2520 2227 1811 9330 1928 5140 4030 4824 806 3134 1632 8171 1435 3366 6543 3745 9286 8509 4645
55	7397 5790 8972 6397 4422 1799 9276 4041 3847

(suite)

Adresses des accumulateurs de bits de parité (débit 2/5)

8683 7378 4946
5348 1993 9186
6724 9015 5646
4502 4439 8474
5107 7342 9442
1387 8910 2660

11. Émetteur (200) selon la revendication 10, comprenant en outre :

un modulateur (205) configuré pour moduler le signal codé LDPC.

12. Émetteur (200) selon la revendication 11, dans lequel le signal modulé est transmis sur une liaison par satellite (103), pour le support d'une application satellitaire à large bande.

13. Émetteur (200) selon la revendication 11, dans lequel la modulation est exécutée selon une constellation de signal comprenant l'un des modes de modulation suivants : 8-PSK (pour « *Phase Shift Keying* »), 16-QAM (pour « *Quadrature Amplitude Modulation* »), QPSK (pour « *Quadrature Phase Shift Keying* »), 16-APSK (pour « *Amplitude Phase Shift Keying* ») et 32-APSK.

FIG. 1

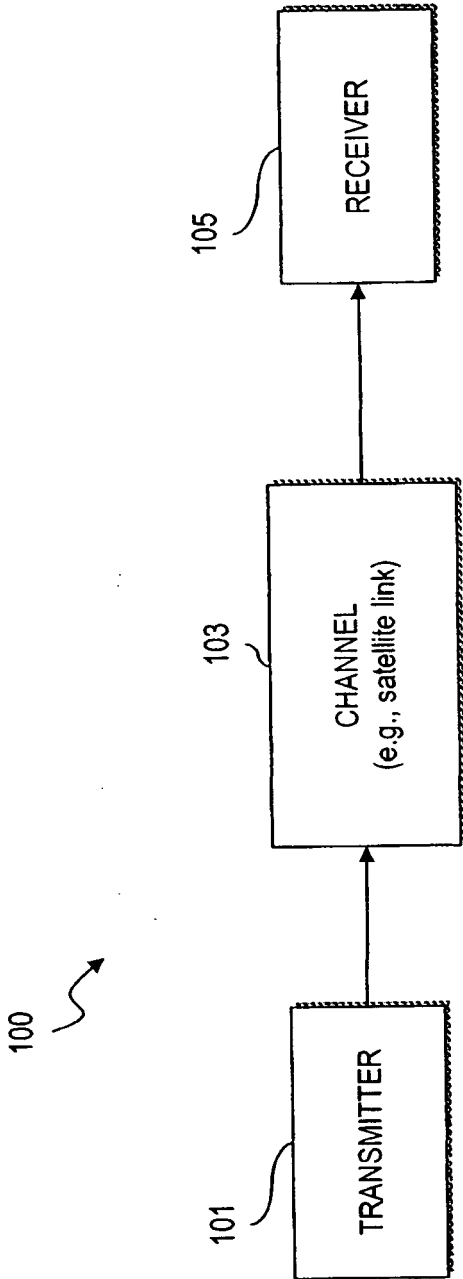


FIG. 2A

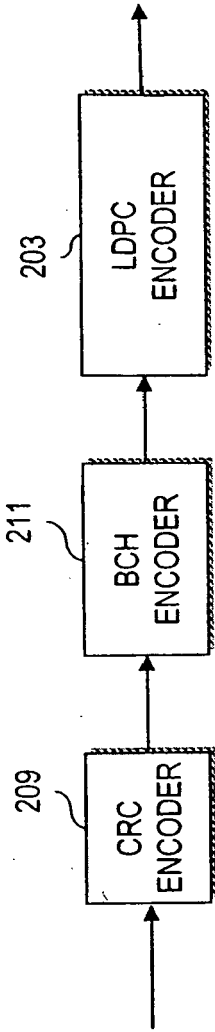
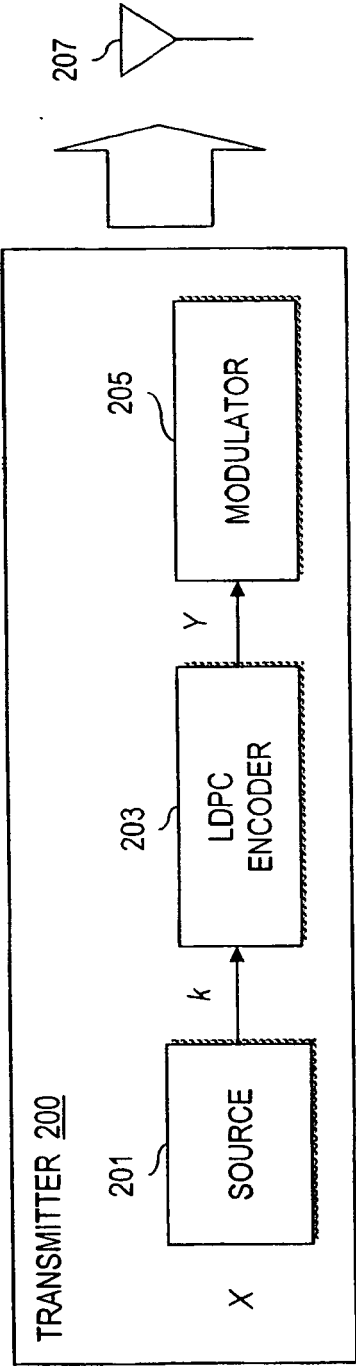


FIG. 2B

FIG. 2C

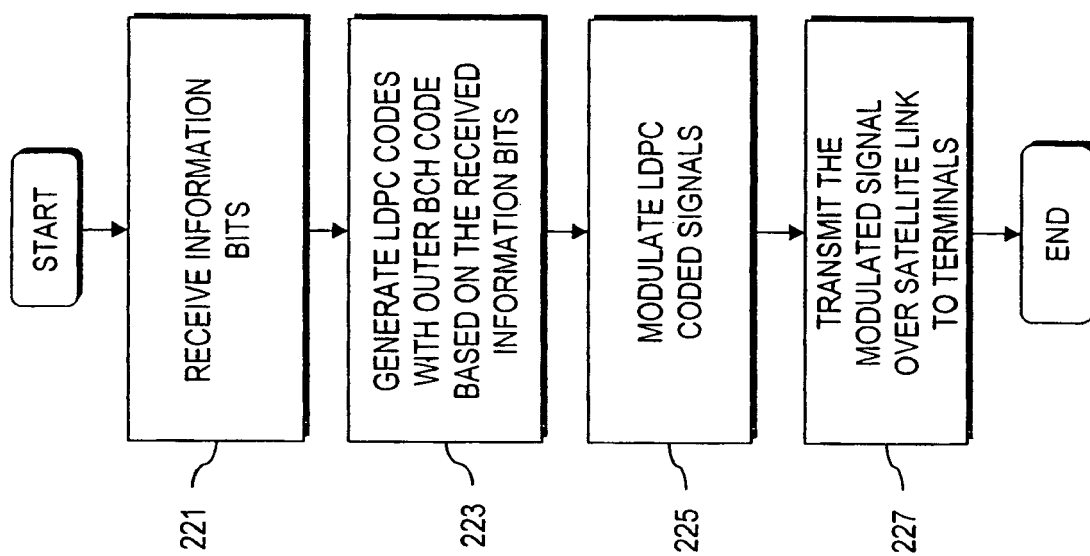


FIG. 2D

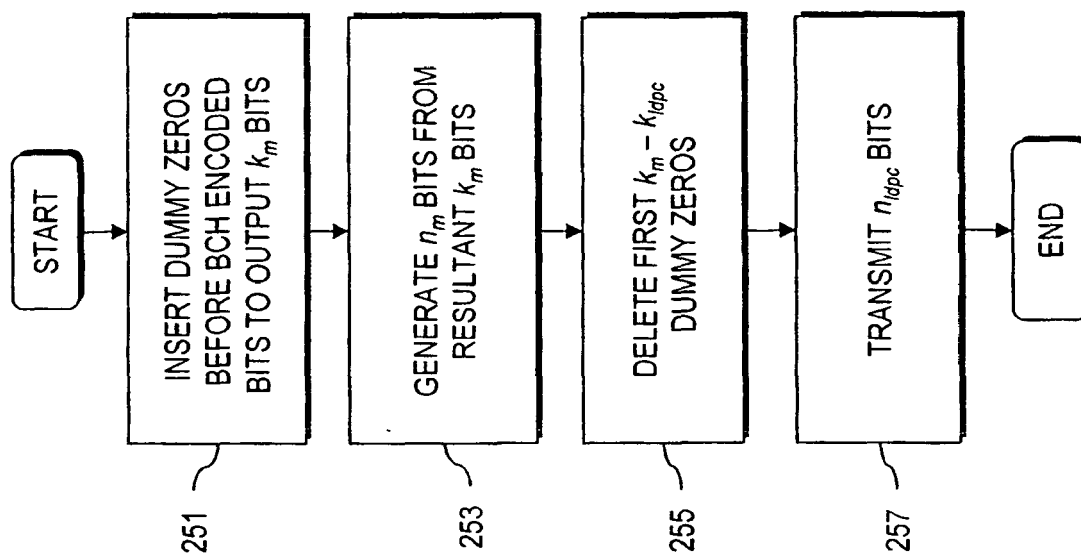


FIG. 3

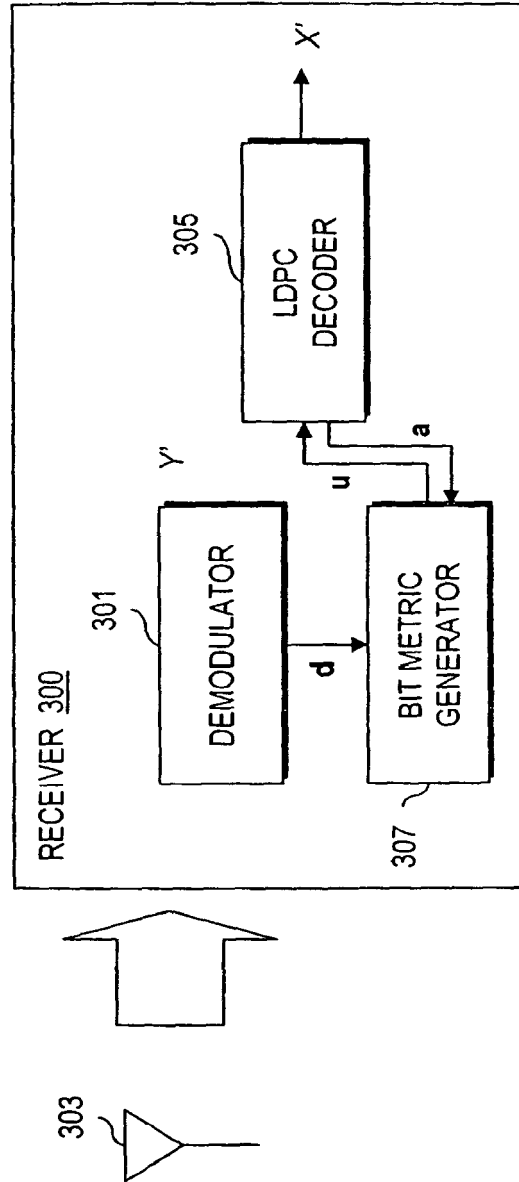


FIG. 4

$$H = \begin{matrix} & n_1 & n_2 & n_3 & n_4 & n_5 & n_6 & n_7 & n_8 \\ \begin{matrix} m_1 \\ m_2 \\ m_3 \\ m_4 \end{matrix} & \begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 & 1 & 0 \end{bmatrix} \end{matrix}$$

FIG. 5

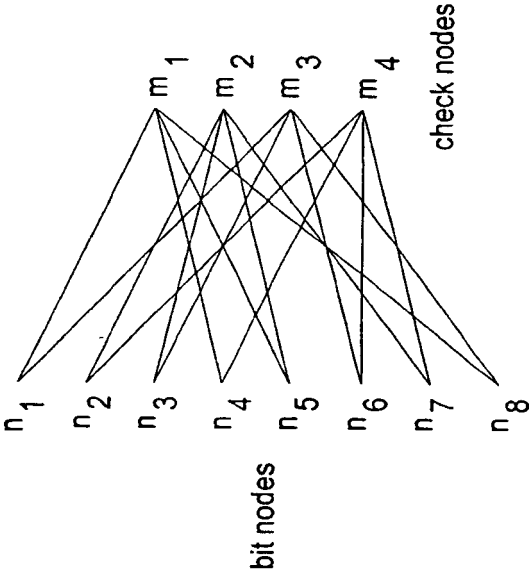


FIG. 6

$$B = \begin{bmatrix} 1 & & & & & & & \\ & 1 & & & & & & \\ & & 1 & & & & & \\ & & & 1 & & & & \\ & & & & 1 & & & \\ & & & & & 1 & & \\ & & & & & & 1 & \\ & & & & & & & 1 \end{bmatrix}$$

FIG. 7

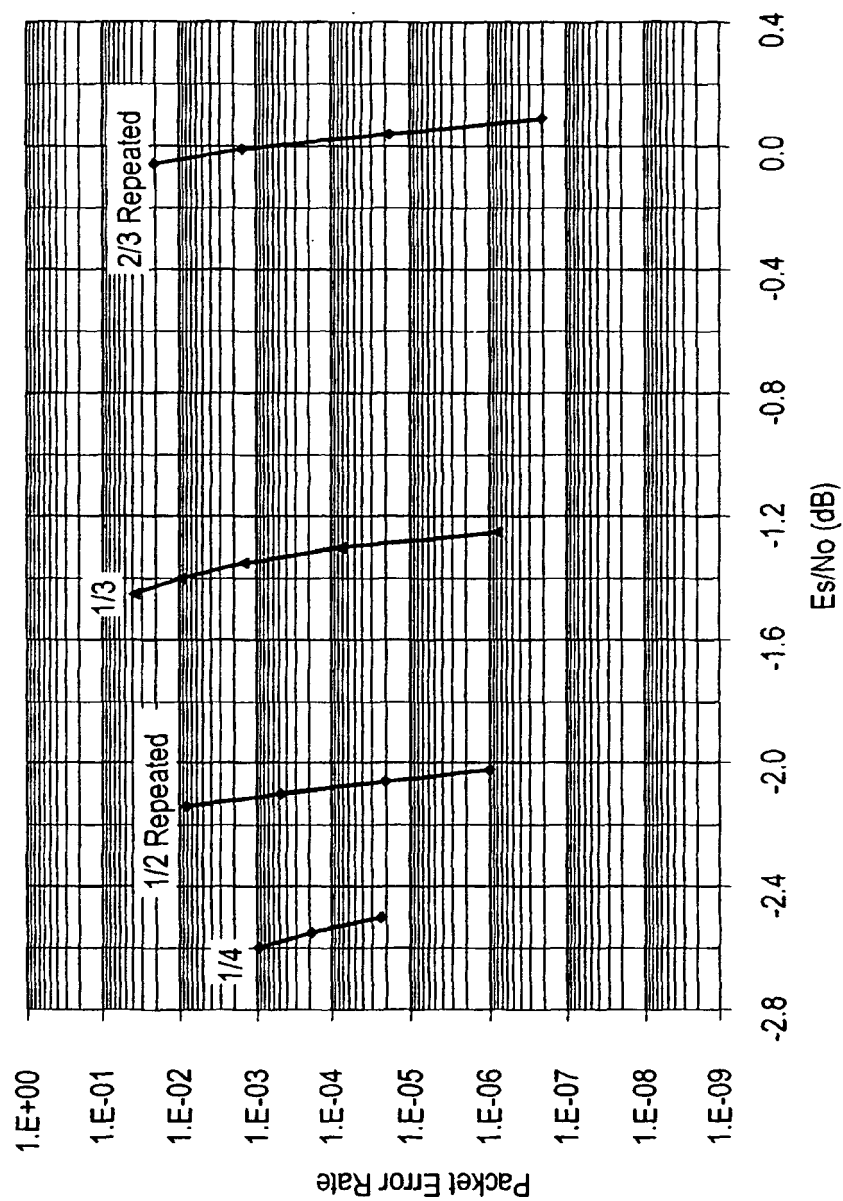
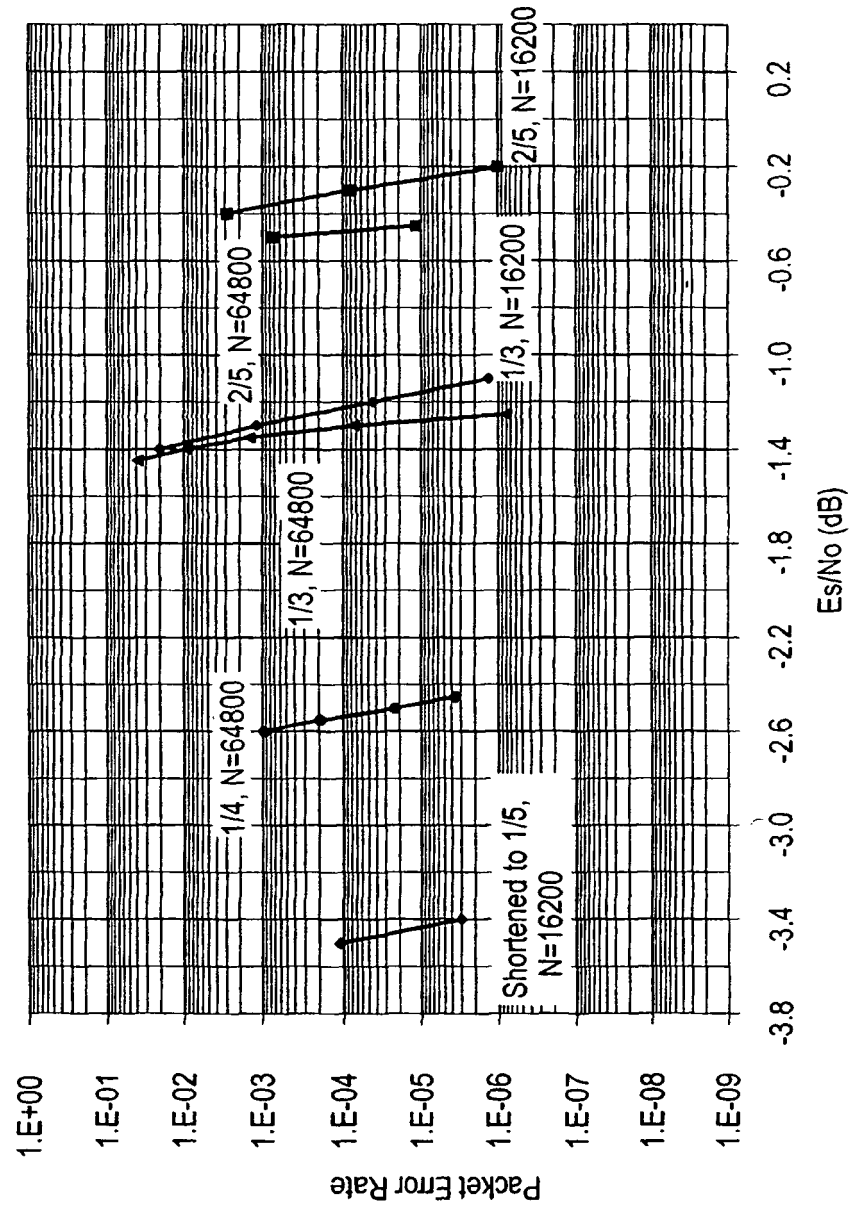


FIG. 8



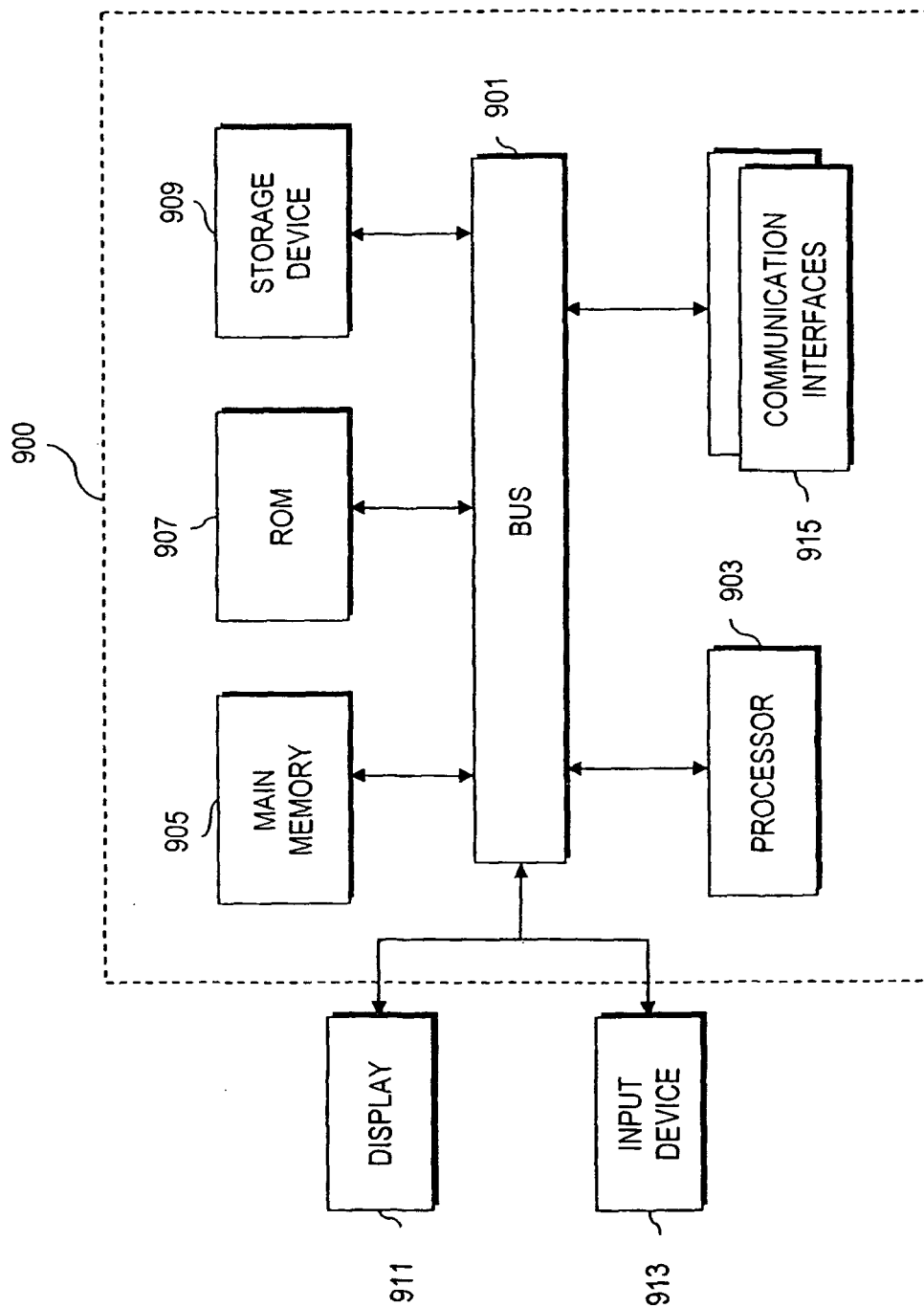


FIG. 9

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 10613824 B [0035]

Non-patent literature cited in the description

- YU Y. et al. describes multilevel coded modulation using semi-algebraic LDPC codes. *Design of semi-algebraic low density parity-check (SA-LDPC) codes for multilevel coded modulation* [0005]