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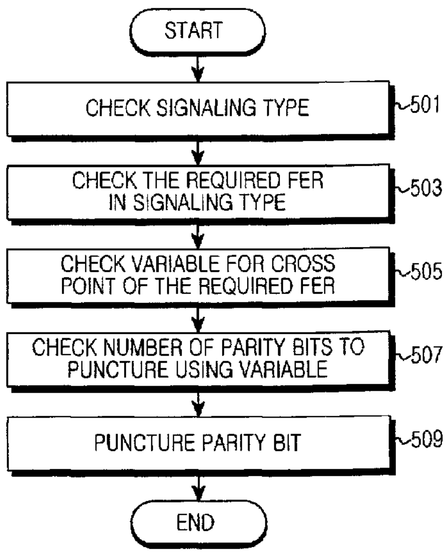
(54) Titre : APPAREIL ET PROCEDE D'EMISSION ET DE RECEPTION DE DONNEES DANS UN SYSTEME DE COMMUNICATION
(54) Title: APPARATUS AND METHOD FOR TRANSMITTING AND RECEIVING DATA IN COMMUNICATION SYSTEM



(57) Abrégé/Abstract:
In broadcasting communication systems, error-correcting code reduces information distortion. When parity bits (N_{tx_pnty}) required by the transmitter are smaller than parity bits N_{parity} output from the encoder, the transmitter punctures N_{parity} - N_{tx_parity} bits. When punctured bits increase, code rate increases and BER/FER performance can get worse than non-punctured code. An inventive method for adaptively selects numbers of shortened bits and punctured bits stabilize the system. A method of a transmitter comprises: obtaining signaling data encoded using a BCH code or low density parity check code; and puncturing signaling data according to the number of puncture bits determined using a first parameter, relating to ratio of the number of bits to be punctured and number of bits to be shortened, and a second parameter, which is an integer. Multiplying the first parameter by a number of shortened bits and adding the second parameter provides the number of puncture bits.

ABSTRACT

In broadcasting communication systems, error-correcting code reduces information distortion. When parity bits (N_{tx_panty}) required by the transmitter are smaller than parity bits N_{parity} output from the encoder, the transmitter punctures N_{parity} - N_{tx_parity} bits. When punctured bits increase, code rate increases and BER/FER performance can get worse than non-punctured code. An inventive method for adaptively selects numbers of shortened bits and punctured bits stabilize the system. A method of a transmitter comprises: obtaining signaling data encoded using a BCH code or low density parity check code; and puncturing signaling data according to the number of puncture bits determined using a first parameter, relating to ratio of the number of bits to be punctured and number of bits to be shortened, and a second parameter, which is an integer. Multiplying the first parameter by a number of shortened bits and adding the second parameter provides the number of puncture bits.

Description

Title of Invention: APPARATUS AND METHOD FOR TRANSMITTING AND RECEIVING DATA IN COMMUNICATION SYSTEM

This is a divisional application of Canadian Patent Application Serial No. 2,818,126 filed on December 2, 2011.

Technical Field

[1] The present invention relates generally to an apparatus and method for transmitting and receiving data in a broadcasting communication system and, more particularly, to an apparatus and a method for controlling a code rate according to data transmission and reception in a broadcasting communication system.

It should be understood that the expression "the invention" and the like used herein may refer to subject matter claimed in either the parent or the divisional applications.

Background Art

[2] Link performance of a broadcasting communication system may degrade due to noise, fading, and Inter-Symbol Interference (ISI). Thus, in order to realize high-speed digital broadcasting communication systems requiring high data throughput and high reliability, it is essential to develop techniques for overcoming the noise, fading, and ISI. In this regard, research has been conducted on error-correcting code for enhancing the communication reliability by efficiently reducing the information distortion. For example, error-correcting codes include Low Density Parity Check (LDPC) code.

[3] Using the LDPC code, an encoder receives an information word including K_{LDPC}-ary bits or symbols and outputs K_{parity}-ary codeword bits or codeword symbols. When the information word bits (K_{sig}) which is input into the encoder are smaller than the information word bits K_{LDPC}, a transmitter shortens K_{LDPC}-K_{sig} bits, and the encoder receives K_{sig} bits. When parity bits (N_{tx_parity}) which is required by the transmitter are smaller than parity bits N_{parity} output from the encoder, the transmitter punctures N_{parity} - $N_{tx\text{-}parity}$ bits.

[4] When the shortened bits increase, the code rate decreases. Thus, Bit Error Rate (BER)/Frame Error Rate (FER) performance of the code can get better than the non-shortened code. Meanwhile, when the punctured bits increase, the code rate increases and thus the BER/FER performance can get worse than the non-punctured code. Accordingly, a method for adaptively selecting the number of the shortened bits and the number of the punctured bits based on the length of the information word is required so that similar performance can be maintained irrespective of the information word

length, in order to make the system more stable.

Disclosure of Invention

Solution to Problem

[5] The present invention is designed to address at least the above-mentioned problems

and/or disadvantages and to provide at least the advantages described below.

Accordingly, an aspect of the present invention to provide an apparatus and a method for transmitting and receiving data in a broadcasting communication system.

[6] Another aspect of the present invention is to provide an apparatus and a method for controlling a code rate in a broadcasting communication system.

[7] Yet another aspect of the present invention is to provide an apparatus and a method for adaptively selecting a shortening/puncturing rate according to a length of an information word in a broadcasting communication system.

[8] According to another aspect of the present invention there is provided a method for transmitting and receiving a signal in a communication system, the method comprising:

checking a type of a signal to be transmitted;

determining the number of puncture bits according to the type of the signal; and

puncturing an encoded signal to be transmitted according to the number of puncture bits.

[9] In some embodiments, the method further comprises:

after checking the type of the signal, checking a performance required in the communication system according to the type of the signal,

wherein determining a number of puncture bits comprises:

determining a number of puncture bits according to the performance required by the communication system.

[10] According to a further aspect of the present invention there is provided an apparatus for transmitting and receiving a signal in a communication system, the apparatus comprising:

an encoder for encoding the signal to be transmitted;

a puncture controller for determining a number of puncture bits according to a type of the signal; and

a puncturer for puncturing a codeword output from the encoder based on the number of puncture bits determined by the puncture controller.

[11] In some embodiments the puncture controller for checking a performance required in the communication system according to a type of the signal, and determining a

number of puncture bits according to the performance required by the communication system.

In some embodiments determining the number of puncture bits comprises:
determining a variable for determining the number of puncture bits according to the performance required by the communication system; and
determining the number of puncture bits using the variable.

In some embodiments determining the number of puncture bits comprises:
determining the number of puncture bits based on:

$$N_{punc} = \lfloor A \times (K_{bch} - K_{sig}) - B \rfloor \quad \text{where } 0 \le B$$

where N_{punc} denotes the number of the punctured bits, A denotes a ratio of the punctured bits to shortened bits, K_{bch} denotes an information word length of a Bose, Chaudhuri, Hocquenghem (BCH) code, K_{sig} denotes the number of bits of the information word input to an encoder, and B denotes a correction factor.

In some embodiments determining the number of puncture bits comprises:
determining the number of puncture bits based on:

$$N_{punc} = \lfloor A \times (K_{bch} - K_{sig}) + B \rfloor \quad \text{where } 0 \le B < N_{parity} - A(K_{bch} - K_{sig\_\min})$$

where N_{punc} denotes the number of the punctured bits, A denotes a ratio of the punctured bits to shortened bits, K_{bch} denotes an information word length of a BCH code, K_{sig} denotes the number of bits of an information word input to an encoder, B denotes a correction factor, and K_{sig_min} denotes the number of bits of the smallest information word among information words input to the encoder.

In some embodiments determining the variable comprises:
determining at least one of A and B according to the required performance.

According to a further aspect of the present invention there is provided a method for receiving a signal in a communication system, the method comprising:
receiving a signal;
determining a type of the received signal;
determining the number of bits punctured in the received signal at a transmitter according to the type of the signal;
adding a number corresponding to the determined number of bits punctured at the transmitter to a demodulated signal of the received signal; and
decoding the added demodulated signal.

In some embodiments the type of the signal to be transmitted comprises at least one of L1-pre, L1-config, L1-dyn, and a transmission location of parity bits of a transmitted information word.

In some embodiments, the method further comprises determining a required performance in a communication system according to the type of the signal, and wherein determining the number of punctured bits is determining the number of punctured bits according to the performance required by the communication system.

According to a further aspect of the present invention there is provided an apparatus for receiving a signal in a communication system, the apparatus comprising:

a puncture controller for determining the number of bits punctured in a received signal at a transmitter according to s type of the received signal;

a puncture processor for adding a number corresponding to the determined number of bits punctured at the transmitter to the received signal demodulated by a demodulator; and

a decoder for decoding the added demodulated signal.

In some embodiments the puncture controller determines a required performance in a communication system according to the type of the received signal, and determines the number of punctured bits according to the performance required by the communication system.

In some embodiments the puncture controller checks the performance required by the communication system based on the signal type comprising at least one of L1-pre, L1-config, L1-dyn, and a transmission location of parity bits of a transmitted information word.

In some embodiments the performance required by the communication system comprises Frame Error Rate (FER) performance required by the communication system.

According to a further aspect of the present invention there is provided a method of a transmitter, the method comprising:

identifying a type of signaling data, wherein the signaling data is encoded using at least one of a Bose, Chaudhuri, Hocque-nghem (BCH) code or a low density parity check (LDPC) code, and the type of the signaling data is related to a protection level of the signaling data;

determining a first parameter and a second parameter based on the type of the signaling data, wherein the first parameter is related to a ratio of a number of bits to be punctured to a number of bits to be shortened, and the second parameter is an integer value;

determining a number of puncture bits using the first parameter and the second parameter; and

puncturing the signaling data based on the number of puncture bits,

wherein the number of puncture bits is determined based on multiplying the first parameter by a number of shortened bits to obtain a multiplication result, and adding the second parameter to the multiplication result.

According to a further aspect of the present invention there is provided an apparatus of a transmitter, the apparatus comprising:

a controller configured to:

identify a type of signaling data, wherein the signaling data is encoded using at least one of a Bose, Chaudhuri, Hocque-nghem (BCH) code or a low density parity check (LDPC) code, and the type of the signaling data is related to a protection level of the signaling data,

determine a first parameter and a second parameter based on the type of the signaling data, wherein the first parameter is related to a ratio of a number of bits to be punctured to a number of bits to be shortened, and the second parameter is an integer value, and

determine a number of puncture bits using the first parameter and the second parameter; and

a puncturer configured to puncture the signaling data based on the number of puncture bits,

wherein the number of puncture bits is determined based on multiplying the first parameter by a number of shortened bits to obtain a multiplication result, and adding the second parameter to the multiplication result.

According to a further aspect of the present invention there is provided a method of a receiver, the method comprising:

identifying a type of signaling data in a received signal, wherein the signaling data is encoded using at least one of a Bose, Chaudhuri, Hocque-nghem (BCH) code or a low density parity check (LDPC) code, and the type of the signaling data is related to a protection level of the signaling data;

determining a first parameter and a second parameter based on the type of the signaling data, wherein the first parameter is related to a ratio of a number of bits to be punctured to a number of bits to be shortened, and the second parameter is an integer value;

determining a number of puncture bits using the first parameter and the second parameter;

obtaining an output signal by appending at least one bit value based on the number of puncture bits to the signaling data; and

decoding the output signal,

wherein the number of puncture bits is determined based on multiplying the first parameter by a number of shortened bits to obtain a multiplication result, and adding the second parameter to the multiplication result.

According to a further aspect of the present invention there is provided an apparatus of a receiver, the apparatus comprising:

a controller configured to:

identify a type of signaling data in a received signal, wherein the signaling data is encoded using at least one of a Bose, Chaudhuri, Hocque-nghem (BCH) code or a low density parity check (LDPC) code, and the type of the signaling data is related to a protection level of the signaling data,

determine a first parameter and a second parameter based on the type of the signaling data, wherein the first parameter is related to a ratio of a number of bits to be punctured to a number of bits to be shortened, and the second parameter is an integer value, and

determine a number of puncture bits using the first parameter and the second parameter;

a processor configured to obtain an output signal by appending at least one bit value based on the number of puncture bits to the signaling data; and

a decoder configured to decode the output signal,

wherein the number of puncture bits is determined based on multiplying the first parameter by a number of shortened bits to obtain a multiplication result, and adding the second parameter to the multiplication result.

Brief Description of Drawings

[12] The above and other aspects, features, and advantages of certain embodiments of the present invention will be more apparent from the following description taken in conjunction with the accompanying drawings, in which:

[13] FIG. 1 illustrates code rate variation according to an embodiment of the present

invention;

[14] FIG. 2 illustrates code rate variation according to another embodiment of the present invention;

[15] FIGS. 3A and 3B illustrate points of intersection according to an embodiment of the present invention;

[16] FIGS. 4A and 4B illustrate points of intersection according to another embodiment of the present invention;

[17] FIG. 5 illustrates a method for puncturing a parity bit based on a signaling type according to an embodiment of the present invention;

[18] FIG. 6 illustrates a frame for carrying parity bits of two types according to an embodiment of the present invention;

[19] FIG. 7 illustrates a puncturing method according to a parity bit type according to an embodiment of the present invention;

[20] FIG. 8 illustrates a method for determining the number of puncture bits according to one embodiment of the present invention;

[21] FIG. 9 illustrates a method for determining the number of puncture bits according to another embodiment of the present invention;

[22] FIG. 10 illustrates a flow chart for receiver operation according to an embodiment of the present invention;

[23] FIG. 11 illustrates a transmitter according to an embodiment of the present invention;

[24] FIG. 12 illustrates a receiver according to an embodiment of the present invention; and

[25] FIG. 13 illustrates a codeword according to an embodiment of the present invention.

[26] Throughout the drawings, like reference numerals will be understood to refer to like parts, components and structures.

Best Mode for Carrying out the Invention

[27] The following description with reference to the accompanying drawings is provided to assist in a comprehensive understanding of embodiments of the invention as defined by the claims and their equivalents. It includes various details to assist in that understanding but these should be regarded as examples . Accordingly, those of ordinary skill in the art will recognize that various changes and modifications of the embodiments described herein can be made without departing from the scope and spirit of the invention. Additionally, descriptions of well-known functions and constructions may be omitted for clarity and conciseness.

[28] The terms and words used in the following description and claims are not limited to the dictionary meanings, but, are merely used by the inventor(s) to enable a clear and consistent understanding of the invention. Accordingly, it should be apparent to those

skilled in the art that the following description of embodiments of the present invention is provided for illustrative purposes only and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

[29] It is to be understood that the singular forms "a," "an," and "the" include plural referents unless the context clearly dictates otherwise.

[30] The term "substantially" means that the recited characteristic, parameter, or value need not be exact, but that deviations or variations, including for example, tolerances, measurement error, measurement accuracy limitations and other factors known to those of skill in the art, may occur in amounts that do not preclude the effect the characteristic was intended to provide.

[31] Embodiments of the present invention provide a technique for controlling a code rate based on data transmission and reception in a communication system.

[32] Hereinafter, descriptions are based on Digital Video Broadcasting (DVB)-the 2nd Generation Terrestrial (T2) system and DVB-Next Generation Handheld (NGH) system, which are European DVB standards. However, the code rate can also be controlled in other systems.

[33] While it is assumed that the code rate is controlled according to transmission of signaling information, the code rate can also be controlled when other information is transmitted.

[34] In a transmitter of a broadcasting communication system, the signaling information of an information word input to an encoder is of a variable length. The transmitter can shorten the information word input into the encoder or puncture the codeword output from the encoder. For example, when the information word including K_{sig}-ary bits is input to the encoder and K_{LDPC}-K_{sig} bits are shortened, the number of the punctured bits for the shortened bits can be determined based on Equations (1), (2), (3) and (4), as shown below It is assumed that the encoder employs a concatenated coding scheme of a Bose, Chaudhuri, Hocquenghem (BCH) and Low Density Parity Check (LDPC) encoder.

[35] When an LDPC code and a BCH code are concatenated and the information word length of the BCH code is K_{bch}, the number of the shortened bits is K_{bch}-K_{sig} and, thus, the number of punctured bits can be determined based on Equation (1).

[36] $$N_{punc} = \lfloor A \times (K_{bch} - K_{sig}) - B \rfloor \text{ where } 0 \leq B \ldots(1)$$

[37] In Equation (1), N_{punc} denotes the number of the punctured bits, A denotes a ratio of the punctured bits to the shortened bits, K_{bch} denotes the information word length of the BCH code, K_{sig} denotes the number of bits of the information word input to the encoder after shortening, and B denotes a correction factor.

[38] Meanwhile, when the LDPC code and the BCH code are not concatenated, the

number of the shortened bits is K_{LDPC}-K_{sig} and accordingly the number of the punctured bits can be determined based on Equation (2).

[39] $N_{punc} = \lfloor A \times (K_{LDPC} - K_{sig}) - B \rfloor$ where $0 \leq B$ ...(2)

[40] In Equation (2), N_{punc} denotes the number of punctured bits, A denotes the ratio of punctured bits to the shortened bits, K_{LDPC} denotes the information word length of the LDPC code, K_{sig} denotes the number of bits of the information word input to the encoder after shortening, and B denotes the correction factor.

[41] When the number of the punctured bits is determined based on Equation (1) or Equation (2), the transmitter can encode data at a lower code rate than the code rate of non-shortening and puncturing.

[42] For example, when the LDPC code and the BCH code are concatenated, the number of shortened bits is K_{bch}-K_{sig} and accordingly the number of punctured bits can be determined based on Equation (3).

[43] $N_{punc} = \lfloor A \times (K_{bch} - K_{sig}) + B \rfloor$ where $0 \leq B < N_{parity} - A(K_{bch} - K_{sig\_min})$ ...(3)

[44] In Equation (3), N_{punc} denotes the number of punctured bits, A denotes the ratio of punctured bits to shortened bits, K_{bch} denotes the information word length of the BCH code, K_{sig} denotes the number of bits of the information word input to the encoder after shortening, B denotes the correction factor, and K_{sig_min} denotes the number of bits of the smallest information word among the information words input to the encoder after shortening.

[45] When the LDPC code and the BCH code are not concatenated, the number of the shortened bits is K_{LDPC}-K_{sig} and, accordingly, the number of the punctured bits can be determined based on Equation (4).

[46] $N_{punc} = \lfloor A \times (K_{LDPC} - K_{sig}) + B \rfloor$ where $0 \leq B < N_{parity} - A(K_{LDPC} - K_{sig\_min})$ ...(4)

[47] In Equation (4), N_{punc} denotes the number of punctured bits, A denotes the ratio of punctured bits to the shortened bits, K_{LDPC} denotes the information word length of the LDPC code, K_{sig} denotes the number of bits of the information word input to the encoder after shortening, K_{sig_min} denotes the correction factor, and B denotes the number of bits of the smallest information word among the information words input to the encoder after shortening.

[48] The punctured bits N_{punc} fall below the parity bits N_{parity} only when the condition of $B < N_{parity} - A(K_{LDPC} - K_{sig\_min})$ in Equations (3) and (4) is satisfied.

[49] In Equations (1), (2), (3) and (4), the number of the punctured bits can be adjusted

according to A and B. That is, A and B vary the code rate as shown in FIGS. 1 and 2.

[50] FIG. 1 illustrates the code rate variation according to one embodiment of the present invention.

[51] In FIG. 1, the code rate changes when A=15/4 and B=525 are applied to Equation (1) and when A=15/4 and B=0 are applied to Equation (1) with K_{bch} =754 , K_{LDPC}=864, and K_{LDPC}.

[52] As shown in FIG. 1, the code rate for transmitting the information varies according to the change of B in Equation (1).

[53] FIG. 2 illustrates the code rate variation according to another embodiment of the present invention.

[54] In FIG. 2, the code rate changes when A=15/4 and B=0 are applied to Equation (1), when A=7/2 and B=0 are applied to Equation (1), and A=11/3 and B=0 are applied to Equation (1) with K_{bch}=3072, K_{LDPC}=3240, and N_{LDPC}=16200.

[55] As shown in FIG. 2, the code rate for transmitting the information varies according to the change of A in Equation (1). The greater A is, the higher the code rate.

[56] As stated above, the code rate of the actual transmission and the performance of the transmitted code vary according to A and B. Particularly, there are multiple point of intersections where there is no difference in Bit Error Rate (BER)/Frame Error Rate (FER) performance according to A and B. For example, when A is greater, a relatively high code rate is used for the short-length input bits and the point of intersection occurs at a higher area, as shown in FIG. 3.

[57] FIGS. 3A and 3B illustrate the points of intersection, according to one embodiment of the present invention.

[58] When A is 15/4 in FIG. 2, the code rate is higher than A of 11/3 and the point of intersection generates at FER=10^{-3} as shown in FIG. 3.

[59] For example, when A is small, the code rate is relative low for the short input bits and the point of intersection generates in a low area as shown in FIG. 4A.

[60] FIGS. 4A and 4B depict points of intersection according to another embodiment of the present invention.

[61] When A is 11/3 in FIG. 2, the code rate is lower than A of 15/4 and the point of intersection generates at FER=10^{-4} as shown in FIG. 4.

[62] As such, the code rate varies according to the number of puncture bits determined by A and B, and the point of intersection of the BER/FER differs based on the variation of the code rate.

[63] The transmitter can adaptively select A and B to satisfy the requirement of the signaling as shown in FIG. 5. That is, the transmitter can adaptively select A and B based on the performance required by the system when the parity bits of the signaling are decoded.

[64] FIG. 5 illustrates a method for puncturing the parity bit based on a signaling type according to an embodiment of the present invention.

[65] In step 501, the transmitter checks the signaling type for the transmission. For example, referring to DVB(Digital Video Broadcasting) standard like a DVB-T2 standard (ETSI EN 302 755), physical(L1) signaling information is delivered through L1-pre, L1-config and L1-dyn. In DVB-T2 standard, The L1-pre signaling includes basic information to decode, L1-config signaling includes parameters which remain the same for some duration, and L1-dyn signaling includes parameters which is changeable frequently. The transmitter determines which of L1-pre, L1-config, and L1-dyn is the type of the signaling to transmit.

[66] In step 503, the transmitter checks the required FER based on the signaling type. For example, when the signaling type is L1-pre, the transmitter checks the performance required by the receiver to decode the signal of L1-pre received from the transmitter.

[67] In step 505, the transmitter selects a variable for satisfying the point of intersection of the required FER confirmed in step 503. Herein, the variable includes A and B used to determine the number of puncture bits in Equation (1), (2), (3) and (4).

[68] In step 507, the transmitter checks the number of bits to puncture using the selected variable. For example, the transmitter determines the number of bits to puncture by applying the selected A and B to Equation (1) or (2).

[69] In step 509, the transmitter punctures the parity bit according to the number of bits confirmed in step 507. Next, the transmitter finishes this process.

[70] FIG. 6 illustrates a frame for carrying the parity bits of two types, according to an embodiment of the present invention.

[71] When the transmitter sends the information in the (i+1)-th frame as shown in FIG. 6, the transmitter sends the first parity bits in the (i+1)-th frame together with the information word , and sends the second parity bits 610 in the i-th frame.

[72] The receiver decodes the information word and the first parity bits received in the (i+1)-th frame. When failing to decode the information word and the first parity bits received in the (i+1)-th frame, the receiver decodes them using the second parity bits received in the i-th frame as well. For example, when failing to decode the information word and the first parity bits received in the (i+1)-th frame, the receiver recognizes the signaling decoding failure. Hence, the receiver stores the second parity bits of the (i+1)-th frame and then receives the (i+2)-th frame.

[73] As such, when the receiver decodes the information word, the FER performance required to decode the information word and the first parity bits can differ from the FER performance required to decode the information word and the first parity together with the second parity. Thus, the transmitter can use different A and B of the first parity bits and the second parity bits as shown in FIG. 7.

[74] FIG. 7 illustrates a puncturing method according to the parity bit type according to an embodiment of the present invention.

[75] In step 701, the transmitter checks the signaling type for the transmission. For example, the transmitter checks the first parity bits of the corresponding information word and the second parity bits, as shown in FIG. 6.

[76] In step 703, the transmitter determines whether the checked signaling is the first parity bits.

[77] When the signaling is the first parity bits, the transmitter checks the required FER of the first parity bits in step 705. For example, the transmitter checks the required FER performance when the receiver decodes the information word and the first parity received from the transmitter.

[78] In step 707, the transmitter selects the variable for satisfying the point of intersection of the required FER confirmed in step 705. The variable includes A and B used to determine the number of bits to puncture in Equation (1) and (2).

[79] In step 709, the transmitter checks the number of bits to puncture using the selected variable. For example, the transmitter determines the bits to puncture as shown in FIG. 8.

[80] In step 711, the transmitter sends the parity bits. When there are the bits to puncture in step 709, the transmitter punctures and transmits the parity based on the bits to puncture checked in step 709.

[81] When the signaling is the second parity bits in step 703, the transmitter checks the required FER of the second parity bits in step 713. For example, the transmitter checks the required FER performance when the receiver decodes the information word and the first parity bits together with the second parity bits received from the transmitter.

[82] In step 715 the transmitter selects the variable for satisfying the point of intersection of the required FER. Herein, the variable includes A and B used to determine the number of bits to puncture in Equation (1), (2), (3) and (4).

[83] In step 717, the transmitter checks the number of bits to puncture using the selected variable. For example, the transmitter determines the bits to puncture as shown in FIG. 9.

[84] In step 719, the transmitter checks the number of the additional parity bits. For example, the transmitter determines the length of the second parity bits added to the previous frame of the frame including the information word as shown in FIG. 9.

[85] In step 711, the transmitter sends the parity bits. When there are the bits to puncture in step 717, the transmitter punctures and transmits the parity bits based on the bits to puncture checked in step 717.Next, the transmitter finishes this process.

[86] FIG. 8 illustrates a method for determining the number of puncture bits according to one embodiment of the present invention.

[87] Upon checking the number of bits to puncture in the first parity bits, the transmitter determines the number of temporary puncture bits in step 801. For example, the transmitter determines the temporary puncture bits N_{punc_temp} by applying A and B checked in step 707 of FIG. 7 to Equation (1).

[88] In step 803, the transmitter determines a temporary N_{post}(N_{post_temp}) using the temporary puncture bits. For example, the transmitter determines the temporary N_{post}(N_{post_temp}) based on Equation (5) as shown in FIG. 13. The temporary N_{post} denotes the number of bits temporarily determined for the actual transmission.

[89] $N_{post\_temp} = K_{sig} + N_{bch\_parity} + N_{LDPC} \times (1 - R_{eff\_LDPC}) - N_{punc\_temp}$ ...(5)

[90] In Equation (5), N_{post_temp} denotes the temporary N_{post}, K_{sig} denotes the number of bits of the information word input to the encoder, N_{bch_parity} denotes the parity bit of the BCH code when the BCH code is used, N_{LDPC} denotes the number of codeword bits of the LDPC code, R_{eff_LDPC} denotes the code rate without the puncture and the shortening, and N_{punc_temp} denotes the number of temporary puncture bits. That is, $N_{LDPC} \times (1 - R_{eff\_LDPC}) - N_{punc\_temp}$ represents the number of parity bits prior to the puncturing. When the BCH code is not used, the transmitter sets N_{bch_parity} of Equation (5) to zero.

[91] In step 805, the transmitter determines N_{post} using the temporary N_{post}. The transmitter needs to correct the temporary N_{post} in the case in which the number of the transmitted bits is limited. For example, according to 16 Quadrature Amplitude Modulation (16-QAM), the number of the transmitted bits should be twice the number of bits η_{MOD} of a modulation signal. Accordingly, the transmitter determines the bits N_{post} actually transmitted based on Equation (6) as shown in FIG. 13.

[92]
$$N_{post} = \begin{cases} \left\lceil \frac{N_{post\_temp}}{2\eta_{MOD}} \right\rceil \times 2\eta_{MOD}, \eta_{MOD}=4 \\ \left\lceil \frac{N_{post\_temp}}{\eta_{MOD}} \right\rceil \times \eta_{MOD}, otherwise \end{cases} \quad ...(6)$$

[93] In Equation (6), N_{post} denotes the number of bits actually transmitted bits, η_{MOD} denotes a modulation order, and N_{post_temp} denotes the temporary N_{post}. The modulation order includes 1, 2, 4 and 6 for representing Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK), 16-QAM, and 64-QAM.

[94] In step 807, the transmitter determines the number of bits to puncture in the first parity bits using the temporary puncture bits, N_{post}, and the temporary N_{post}. For example, the transmitter determines the number of bits to puncture in the first parity bits based on Equation (7).

[95] $N_{punc} = N_{punc\_temp} - (N_{post} - N_{post\_temp})$ ...(7)

[96] In Equation (7), N_{punc} denotes the number of bits to puncture in the first parity bits, N_{punc_temp} denotes the number of temporary puncture bits, N_{post} denotes the bits actually transmitted, and N_{post_temp} denotes the temporary N_{post}. Next, the transmitter finishes this process.

[97] FIG. 9 illustrates a method for determining the number of puncture bits according to another embodiment of the present invention.

[98] Upon confirming the number of bits to puncture in the second parity bits, the transmitter determines the number of temporary puncture bits in step 901. For example, the transmitter determines the number of temporary puncture bits N_{punc_temp} by applying A and B confirmed in step 715 of FIG. 7 to Equation (1).

[99] In step 903, the transmitter determines the temporary $N_{post}(N_{post\_temp})$ using the number of temporary puncture bits. For example, the transmitter determines the temporary N_{post} (N_{post_temp}) based on Equation (8).

[100] $N_{post\_temp} = N_{punc} - N_{punc\_temp\_add}$ ...(8)

[101] In Equation (8), N_{post_temp} denotes the temporary N_{post}, N_{punc} denotes the number of puncture bits of the first parity bits, and $N_{post\_temp\_add}$ denotes the number of temporary puncture bits of the second parity bits.

[102] In step 905, the transmitter determines N_{post} using the temporary N_{post}. Herein, the transmitter determines N_{post} based on Equation (6). In step 907, the transmitter determines the number of bits to puncture in the second parity bits using the number of temporary puncture bits, N_{post}, and the temporary N_{post}. For example, the transmitter determines the number of bits to puncture in the second parity bits based on Equation (7).

[103] In step 909, the transmitter determines the number of bits of the second parity bits. For example, the transmitter determines the number of bits of the second parity bits based on Equation (9).

[104] $N_{add\_parity} = N_{punc} - N_{punc\_add\_parity}$ ...(9)

[105] In Equation (9), N_{add_parity} denotes the number of bits of the second parity bits, N_{punc} denotes the number of puncture bits of the first parity bits, and $N_{punc\_add\_parity}$ denotes the number of temporary puncture bits of the second parity bits. Next, the transmitter finishes this process.

[106] A method of receiving a signal from a transmitter in which the signal is shortened and punctured will be described.

[107] FIG. 10 illustrates a flow chart for receiving a signal at receiver according to an embodiment of the present invention. Hereunder, the signal is the signaling information which is shortened and punctured by the transmitter.

[108] Referring Fig. 10, in step 1001, the receiver receives the signal transmitted from the transmitter.

[109] Next, in step 1003, the receiver demodulates the signal considering the modulation scheme at the transmitter. For example, the receiver determines the probability that each bit of the received signal is 1 at the transmitter (probability 1) and probability that each bit of the received signal is 0 at the transmitter (probability 2). Thereafter, the receiver determines a LLR (Log Likelihood Ratio) which is a ratio between the probability 1 and the probability 2.

[110] Next, in step 1005, the received determines the number of bits in the signal which are punctured at the transmitter before transmission. For example, the receiver may determine the number of bits which are punctured at the transmitter according to the signaling type as shown in Fig. 5. In another example, the receiver may determine the number of bits which are punctured at the transmitter according to the signaling type and the parity type as shown in Fig. 7.

[111] After determining the number of bits which are punctured at the transmitter, the receiver, in step 1007, adds the number of bits which are punctured at the transmitter to the demodulated signal. The number of shortened bits may also be added. For example, the receiver adds '0' which is the number of bits which are shortened and punctured at the transmitter to the signal demodulated in step 1003.

[112] Thereafter, the receiver proceeds to the step 1009 to decode the signal to which the number of bits which are shortened and punctured is added. And by decoding, the receiver determines the information word in the received signal from the transmitter. Next, the receiver finishes this process.

[113] As stated above, the receiver determines the number bits which are punctured at the transmitter after demodulation of the received signal.

[114] By the way, the receiver, may determine the number bits which are punctured at the transmitter and then may demodulate the received signal.A structure of the transmitter for adjusting the shortening/puncturing ratio according to the required performance of the system will now be explained.

[115] FIG. 11 illustrates the transmitter structure according to an embodiment of the present invention.

[116] As shown in FIG. 11, the transmitter includes an encoder 1101, a puncturer 1103, a puncture controller 1105, a modulator 1107, and a Radio Frequency (RF) processor 1109.

[117] The encoder 1101 outputs the coded bits generated by encoding the information bits to transmit. For example, when the encoder 1101 is the BCH/LDPC encoder, the encoder 1101 BCH-encodes the K_{bch}-ary information bits and, thus, generates the BCH codeword including the K_{LDPC}-ary bits. The encoder 1001 then generates and outputs the LDPC codeword including the N_{LDPC}-ary bits by LDPC-encoding the BCH codeword.

[118] The puncturer 1103 punctures the codeword output from the encoder 1101 according to a puncture pattern and the number of puncture bits provided from the puncture controller 1105.

[119] The puncture controller 1105 determines the number of puncture bits according to the required performance of the system. For example, the puncture controller 1105 determines A and b in order to satisfy the required performance of the system based on the type of signaling to transmit from the transmitter as shown in FIG. 5. The puncture controller 1105 then determines the number of puncture bits by applying A and B to Equation (1), (2), (3), and (4). For example, the puncture controller 1105 may determine the number of puncture bits according to the parity type as shown in FIG. 7.

[120] The modulator 1107 modulates and outputs the signal fed from the puncturer 1103 according to the corresponding modulation scheme.

[121] The RF processor 1109 converts the modulated signal output from the modulator 1107 to an RF signal and sends the RF signal over an antenna.

[122] As set forth above, the shortening/puncturing ratio is selected adaptively according to the channel state condition required in the communication system. Thus, the system stability is sustained irrespective of the length of the information word.

[123] Additionally, the diversity gain for the signaling information can be achieved by selectively determining the amount of parity bits transmitted over the different frame in the communication system.

[124] A receiver for receiving a signal from a transmitter in which the signal is shortened and punctured will be described.

[125] FIG. 12 illustrates a receiver according to an embodiment of the present invention.

[126] Referring Fig. 12, the receiver may include a RF processor (1201), a demodulator (1203), a puncturing processor (1205), a decoder (1207) and a puncturing controller (1209).

[127] The RF processor (1201) converts a high frequency signal received via an antenna(not shown) to a base band signal and provides the base band signal to the demodulator(1203).

[128] The demodulator (1203) demodulates the signal from the RF processor (1201) according to the corresponding modulation scheme. For example, the demodulator determines the probability that each bit of the received signal is 1 at the modulator (1107) of the transmitter (probability 3) and probability that each bit of the received signal is 0 at the modulator (1107) of the transmitter (probability 4). Thereafter, the demodulator determines a LLR (Log Likelihood Ratio) which is a ratio between the probability 3 and the probability 4.

[129] The puncturing processor (1205) adds the number of bits which are punctured provided from the puncturing controller (1209) to the demodulated signal from the de-

modulator (1203). The number of shortened bits may also be added. For example, the puncturing processor (1205) adds '0' which is the number of bits which are shortened and punctured to the signal demodulated by the demodulator (1203).

[130] The puncturing controller (1209) determines the number of bits in the received signal which are punctured at the transmitter. For example, the puncturing controller (1209) may a A value and a B value which are satisfactory for the performance of a communication system according to the signaling type as shown in Fig. 5. Then, the puncturing controller (1209) may determine the number of bits which are punctured at the transmitter in the received signal according to the above equation 1, equation 2, equation 3 or equation 4. In another example, the puncturing controller (1209) may determine the number of bits which are punctured at the transmitter according to the parity type (and the signaling type) as shown in Fig. 7. Further, the puncturing controller (1209) may determine the number of bits which are punctured at the transmitter based on a received control signal from a controller at the transmitter.

[131] The decoder (1207) decodes a signal from the puncturing processor (1205) and outputs a information word bit. For example, if BCH/LDPC code is used, the decoder (1207) decodes received LLR values in the number of N_{LDPC} and restores bits in the number of N_{LDPC} and outputs information words in the number of K_{BCH} via BCH decoding.

[132] FIG. 13 illustrates a codeword according to an embodiment of the present invention. The codeword is configured as shown and as stated above, for example, the transmitter determines the temporary N_{post} (N_{post_temp}) based on above Equation (5). The temporary N_{post} denotes the number of bits temporarily determined for the actual transmission. In another example, according to 16 Quadrature Amplitude Modulation (16-QAM), the number of the transmitted bits should be twice the number of bits η_{MOD} of a modulation signal. Accordingly, the transmitter determines the bits N_{post} actually transmitted based on above Equation (6).

[133] While the invention has been shown and described with reference to certain embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims and their equivalents.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of a transmitter, the method comprising:

identifying a type of signaling data, wherein the signaling data is encoded using at least one of a Bose, Chaudhuri, Hocque-nghem (BCH) code or a low density parity check (LDPC) code, and the type of the signaling data is related to a protection level of the signaling data;

determining a first parameter and a second parameter based on the type of the signaling data, wherein the first parameter is related to a ratio of a number of bits to be punctured to a number of bits to be shortened, and the second parameter is an integer value;

determining a number of puncture bits using the first parameter and the second parameter; and

puncturing the signaling data based on the number of puncture bits,

wherein the number of puncture bits is determined based on multiplying the first parameter by a number of shortened bits to obtain a multiplication result, and adding the second parameter to the multiplication result.

2. The method of claim 1, wherein the type of the signaling data comprises at least one of L1-pre, L1-config, L1-dyn, and a transmission location of parity bits of a transmitted information word.

3. An apparatus of a transmitter, the apparatus comprising:

a controller configured to:

identify a type of signaling data, wherein the signaling data is encoded using at least one of a Bose, Chaudhuri, Hocque-nghem (BCH) code or a low density parity check (LDPC) code, and the type of the signaling data is related to a protection level of the signaling data,

determine a first parameter and a second parameter based on the type of the signaling data, wherein the first parameter is related to a ratio of a number of bits to be punctured to a number of bits to be shortened, and the second parameter is an integer value, and

determine a number of puncture bits using the first parameter and the second parameter; and

a puncturer configured to puncture the signaling data based on the number of puncture bits,

wherein the number of puncture bits is determined based on multiplying the first parameter by a number of shortened bits to obtain a multiplication result, and adding the second parameter to the multiplication result.

4. The apparatus of claim 3, wherein the type of the signaling data comprises at least one of L1-pre, L1-config, L1-dyn, and a transmission location of parity bits of a transmitted information word.

5. A method of a receiver, the method comprising:

identifying a type of signaling data in a received signal, wherein the signaling data is encoded using at least one of a Bose, Chaudhuri, Hocque-nghem (BCH) code or a low density parity check (LDPC) code, and the type of the signaling data is related to a protection level of the signaling data;

determining a first parameter and a second parameter based on the type of the signaling data, wherein the first parameter is related to a ratio of a number of bits to be punctured to a number of bits to be shortened, and the second parameter is an integer value;

determining a number of puncture bits using the first parameter and the second parameter;

obtaining an output signal by appending at least one bit value based on the number of puncture bits to the signaling data; and

decoding the output signal,

wherein the number of puncture bits is determined based on multiplying the first parameter by a number of shortened bits to obtain a multiplication result, and adding the second parameter to the multiplication result.

6. The method of claim 5, wherein the type of the signaling data comprises at least one of L1-pre, L1-config, L1-dyn, and a transmission location of parity bits of a transmitted information word.

7. An apparatus of a receiver, the apparatus comprising:

a controller configured to:

identify a type of signaling data in a received signal, wherein the signaling data is encoded using at least one of a Bose, Chaudhuri, Hocque-nghem (BCH) code or a low density parity check (LDPC) code, and the type of the signaling data is related to a protection level of the signaling data,

determine a first parameter and a second parameter based on the type of the signaling data, wherein the first parameter is related to a ratio of a number of bits to be punctured to a number of bits to be shortened, and the second parameter is an integer value, and

determine a number of puncture bits using the first parameter and the second parameter;

a processor configured to obtain an output signal by appending at least one bit value based on the number of puncture bits to the signaling data; and

a decoder configured to decode the output signal,

wherein the number of puncture bits is determined based on multiplying the first parameter by a number of shortened bits to obtain a multiplication result, and adding the second parameter to the multiplication result.

8. The apparatus of claim 7, wherein the type of the signaling data comprises at least one of L1-pre, L1-config, L1-dyn, and a transmission location of parity bits of a transmitted information word.

9. The method of claim 1, wherein the type of the signaling data is associated with an error rate required for decoding the signaling data, and

wherein the first parameter and the second parameter are adjusted to control a code rate of the signaling data according to the error rate.

10. The method of claim 1, wherein the number of puncture bits is determined based on:

$$N_{punc} = \lfloor A \times (K_{LDPC} - K_{sig}) + B \rfloor$$

wherein N_{punc} denotes the number of puncture bits, A denotes the first parameter, K_{LDPC} denotes an information word length of the LDPC code, K_{sig} denotes the number of bits of an information word after a shortening of the at least one bit for the LDPC code, and B denotes the second parameter.

11. The apparatus of claim 3, wherein the number of puncture bits is determined based on:

$$N_{punc} = \lfloor A \times (K_{LDPC} - K_{sig}) + B \rfloor$$

wherein N_{punc} denotes the number of puncture bits, A denotes the first parameter, K_{LDPC} denotes an information word length of the LDPC code, K_{sig} denotes the number of bits of an information word after a shortening of the at least one bit for the LDPC code, and B denotes the second parameter.

12. The method of claim 5, wherein the number of puncture bits is determined based on:

$$N_{punc} = \lfloor A \times (K_{LDPC} - K_{sig}) + B \rfloor$$

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wherein N_{punc} denotes the number of puncture bits, A denotes the first parameter, K_{LDPC} denotes an information word length of a low density parity check LDPC code, K_{sig} denotes the number of bits of an information word after a shortening of the at least one bit for the LDPC code, and B denotes the second parameter.

13. The apparatus of claim 7, wherein the number of puncture bits is determined based on:

$$N_{punc} = \lfloor A \times (K_{LDPC} - K_{sig}) + B \rfloor$$

wherein N_{punc} denotes the number of puncture bits, A denotes the first parameter, K_{LDPC} denotes an information word length of the LDPC code, K_{sig} denotes the number of bits of an information word after a shortening of the at least one bit for the LDPC code, and B denotes the second parameter.

14. The apparatus of claim 3, wherein the type of the signaling data is associated with an error rate required for decoding the signaling data, and

wherein the first parameter and the second parameter are adjusted to control a code rate of the signaling data according to the error rate.

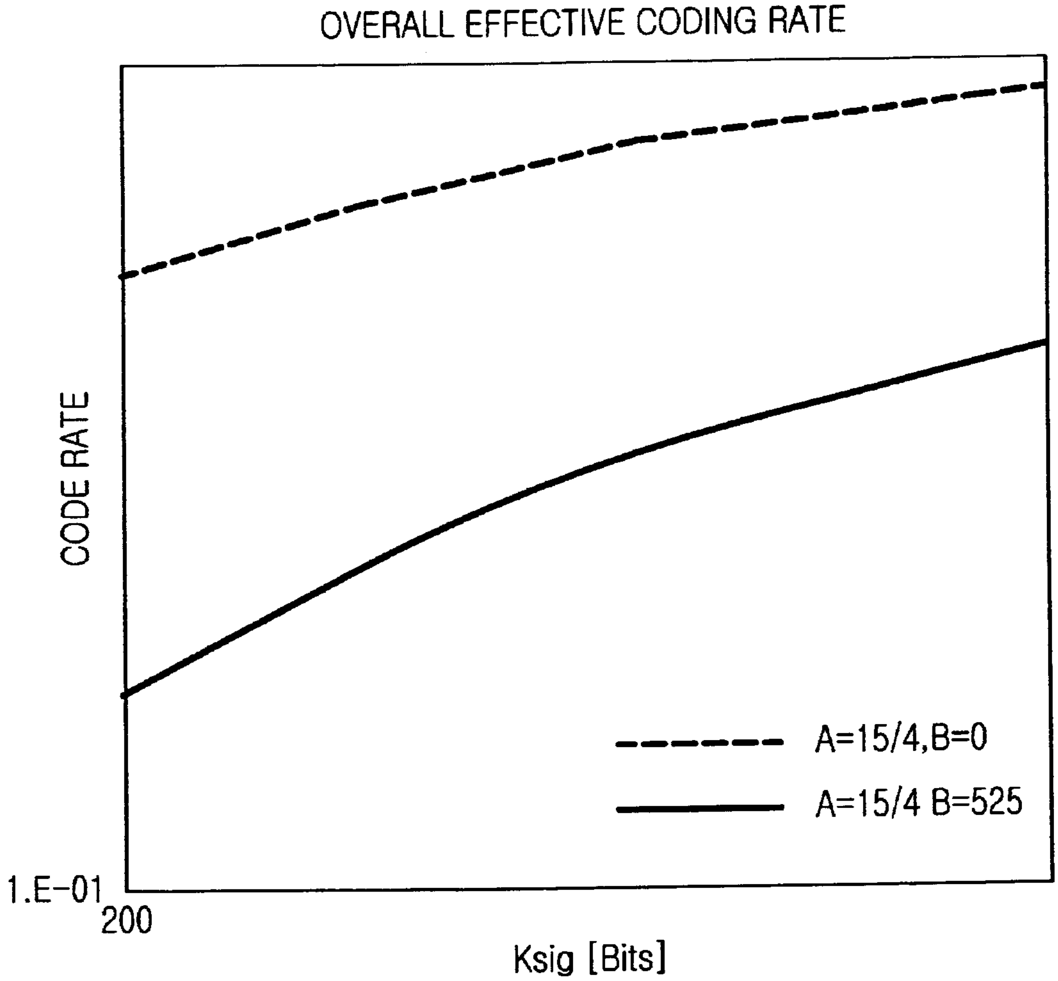
15. The method of claim 5, wherein the type of the signaling data is associated with an error rate required for decoding the signaling data, and

wherein the first parameter and the second parameter are adjusted to control a code rate of the signaling data according to the error rate.

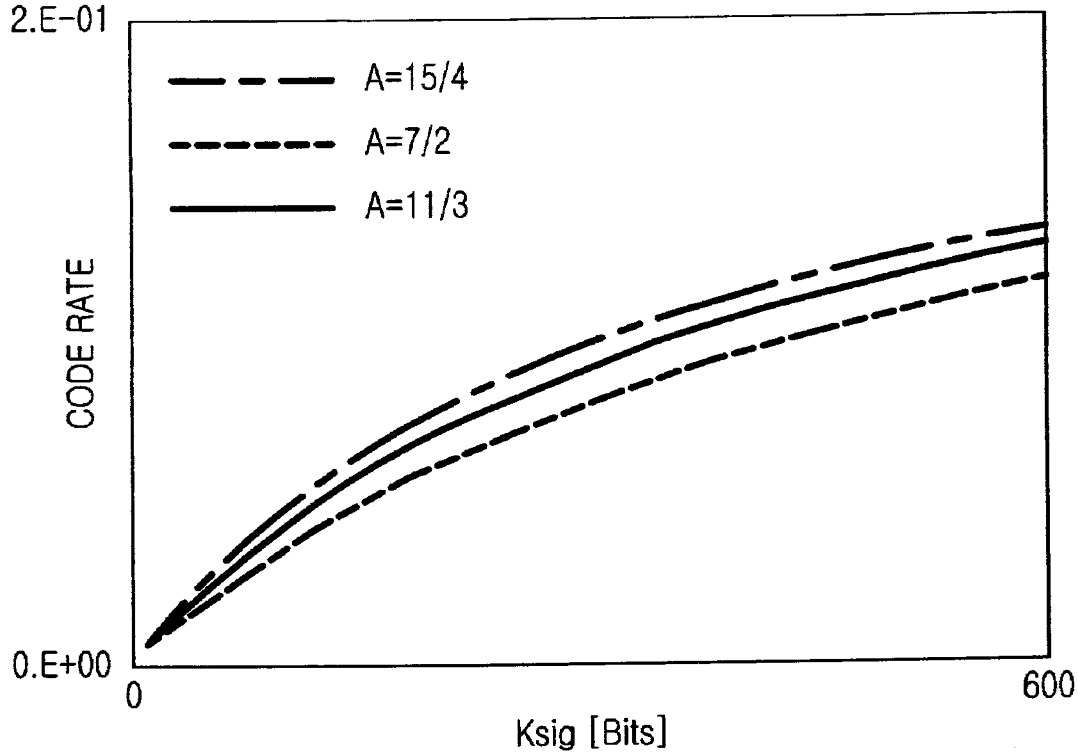
16. The apparatus of claim 7, wherein the type of the signaling data is associated with an error rate required for decoding the signaling data, and

wherein the first parameter and the second parameter are adjusted to control a code rate of the signaling data according to the error rate.

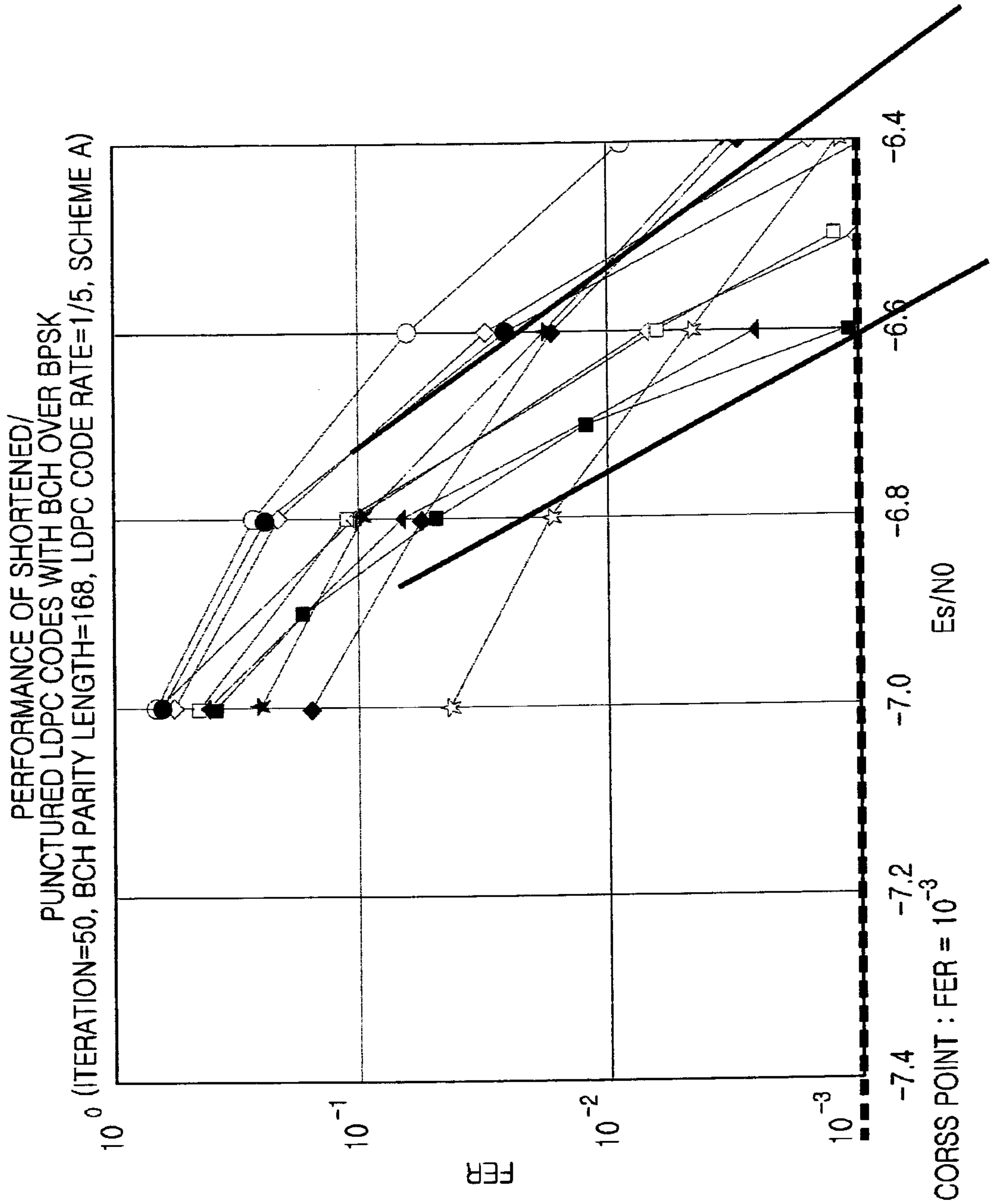
[Fig. 1]


OVERALL EFFECTIVE CODING RATE
CODE RATE
A=15/4,B=0
A=15/4 B=525
1.E-01
200
Ksig [Bits]

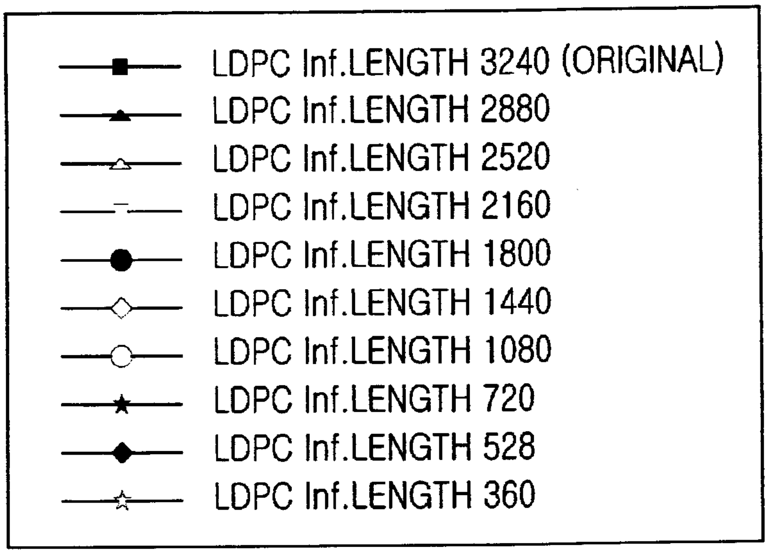
[Fig. 2]



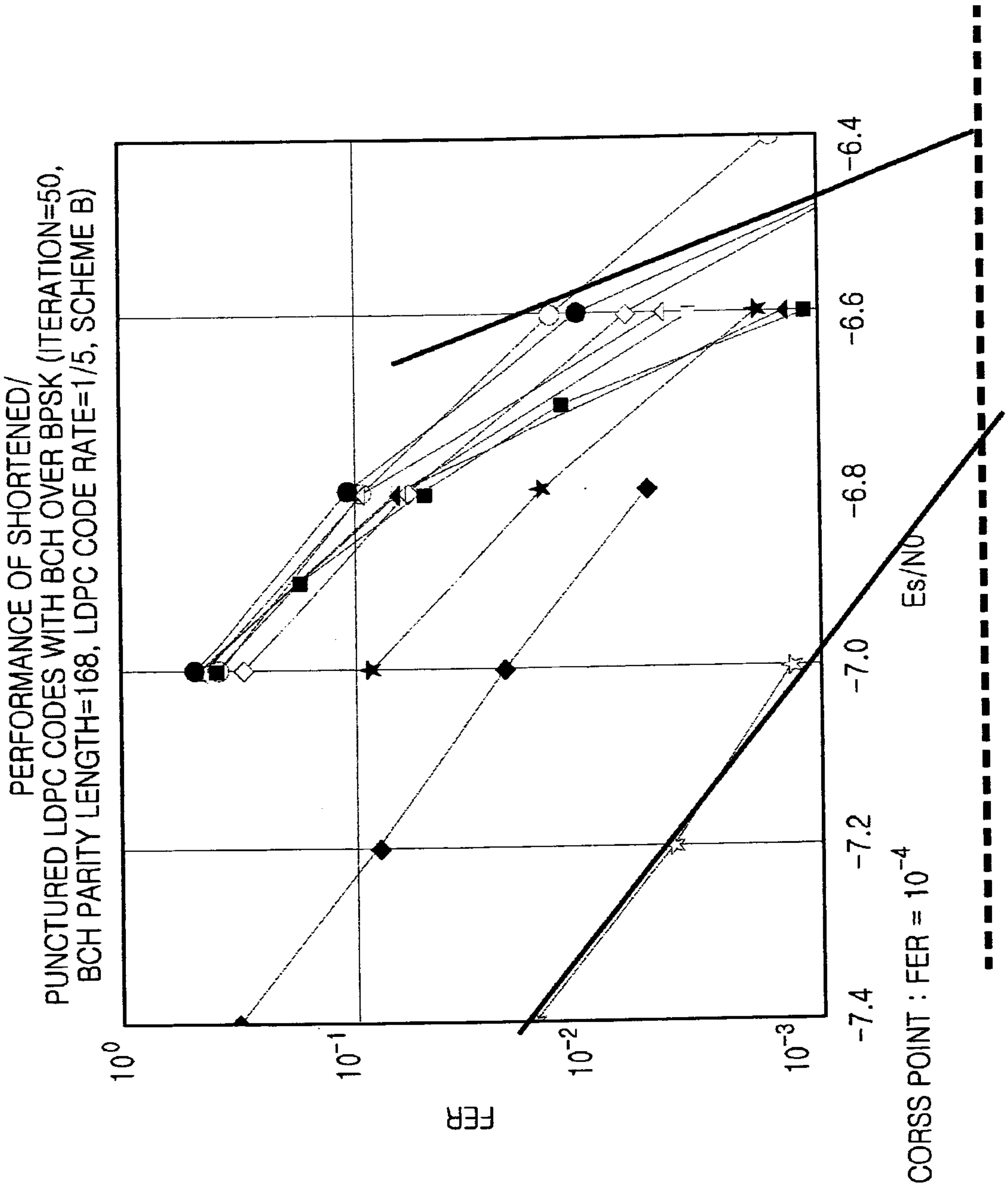
[Fig. 3a]


PERFORMANCE OF SHORTENED/
PUNCTURED LDPC CODES WITH BCH OVER BPSK
(ITERATION=50, BCH PARITY LENGTH=168, LDPC CODE RATE=1/5, SCHEME A)
FER
10^0
10^-1
10^-2
10^-3
-7.4
-7.2
-7.0
-6.8
-6.6
-6.4
Es/N0
CORSS POINT : FER = 10^-3

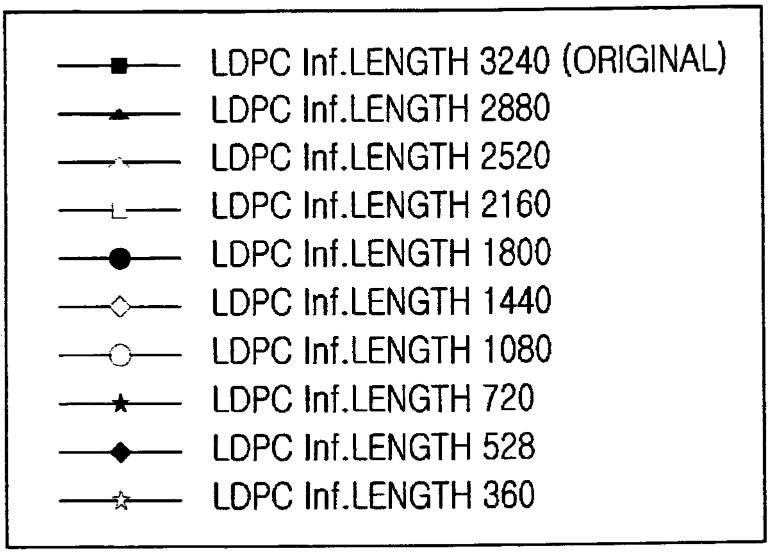
[Fig. 3b]


LDPC Inf.LENGTH 3240 (ORIGINAL)
LDPC Inf.LENGTH 2880
LDPC Inf.LENGTH 2520
LDPC Inf.LENGTH 2160
LDPC Inf.LENGTH 1800
LDPC Inf.LENGTH 1440
LDPC Inf.LENGTH 1080
LDPC Inf.LENGTH 720
LDPC Inf.LENGTH 528
LDPC Inf.LENGTH 360

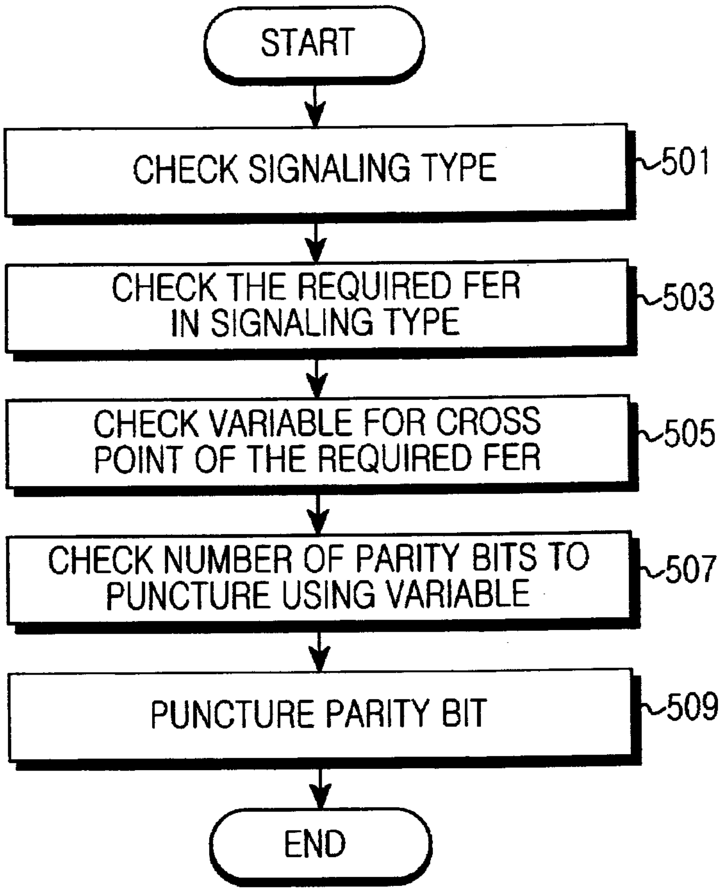
[Fig. 4a]


PERFORMANCE OF SHORTENED/
PUNCTURED LDPC CODES WITH BCH OVER BPSK (ITERATION=50,
BCH PARITY LENGTH=168, LDPC CODE RATE=1/5, SCHEME B)
FER
10^{0}
10^{-1}
10^{-2}
10^{-3}
-7.4
-7.2
-7.0
-6.8
-6.6
-6.4
Es/N0
CORSS POINT : FER = 10^{-4}

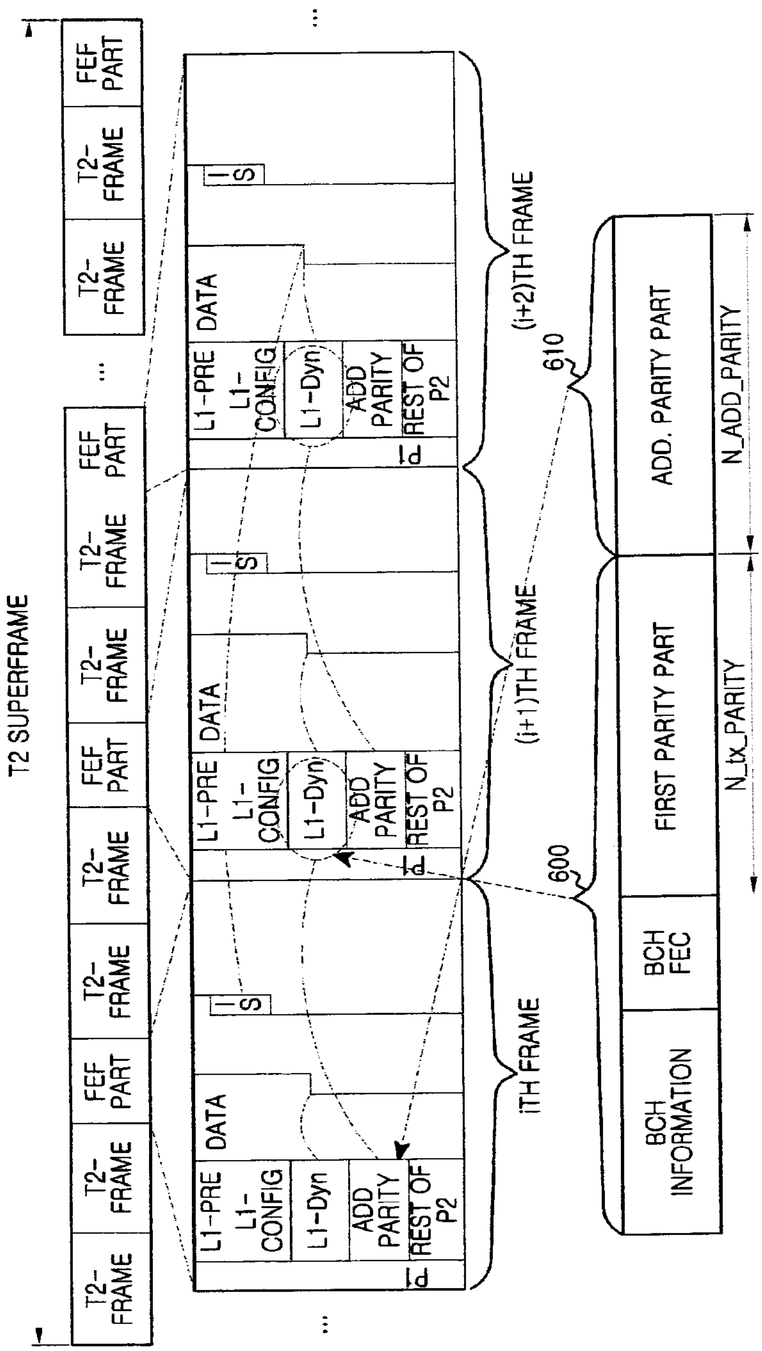
[Fig. 4b]


LDPC Inf.LENGTH 3240 (ORIGINAL)
LDPC Inf.LENGTH 2880
LDPC Inf.LENGTH 2520
LDPC Inf.LENGTH 2160
LDPC Inf.LENGTH 1800
LDPC Inf.LENGTH 1440
LDPC Inf.LENGTH 1080
LDPC Inf.LENGTH 720
LDPC Inf.LENGTH 528
LDPC Inf.LENGTH 360

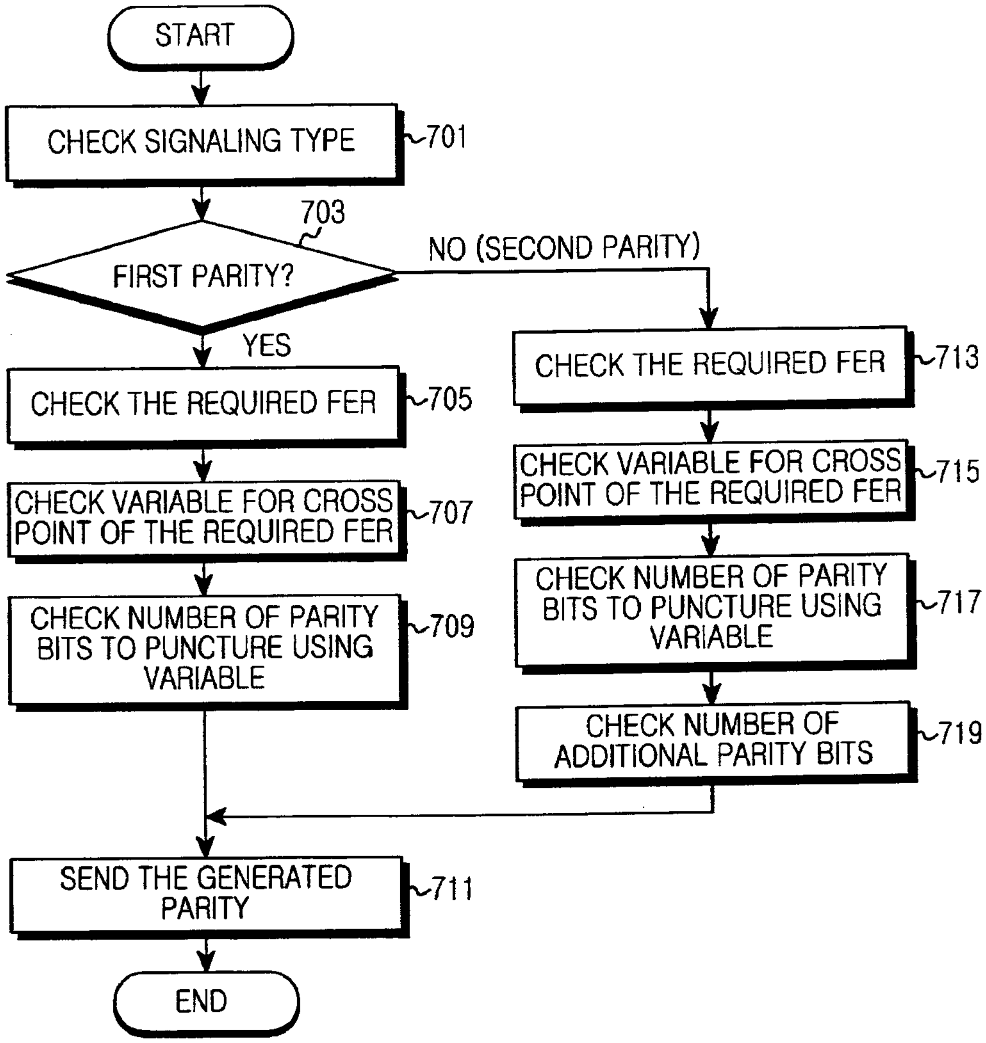
[Fig. 5]


START
CHECK SIGNALING TYPE
501
CHECK THE REQUIRED FER IN SIGNALING TYPE
503
CHECK VARIABLE FOR CROSS POINT OF THE REQUIRED FER
505
CHECK NUMBER OF PARITY BITS TO PUNCTURE USING VARIABLE
507
PUNCTURE PARITY BIT
509
END

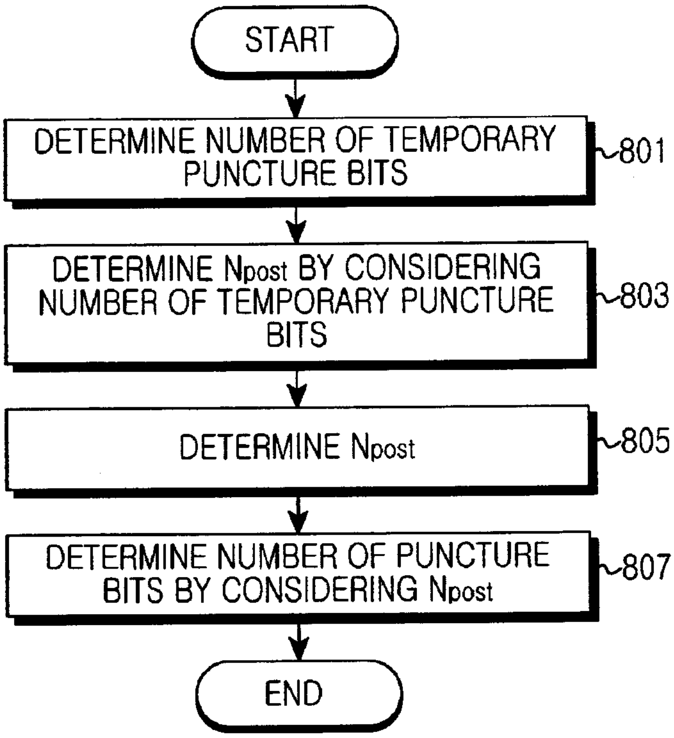
[Fig. 6]


T2 SUPERFRAME
T2-FRAME
FEF PART
L1-PRE
L1-CONFIG
L1-Dyn
ADD PARITY
REST OF P2
P1
DATA
S I
ITH FRAME
(i+1)TH FRAME
(i+2)TH FRAME
600
610
BCH INFORMATION
BCH FEC
FIRST PARITY PART
ADD. PARITY PART
N_tx_PARITY
N_ADD_PARITY

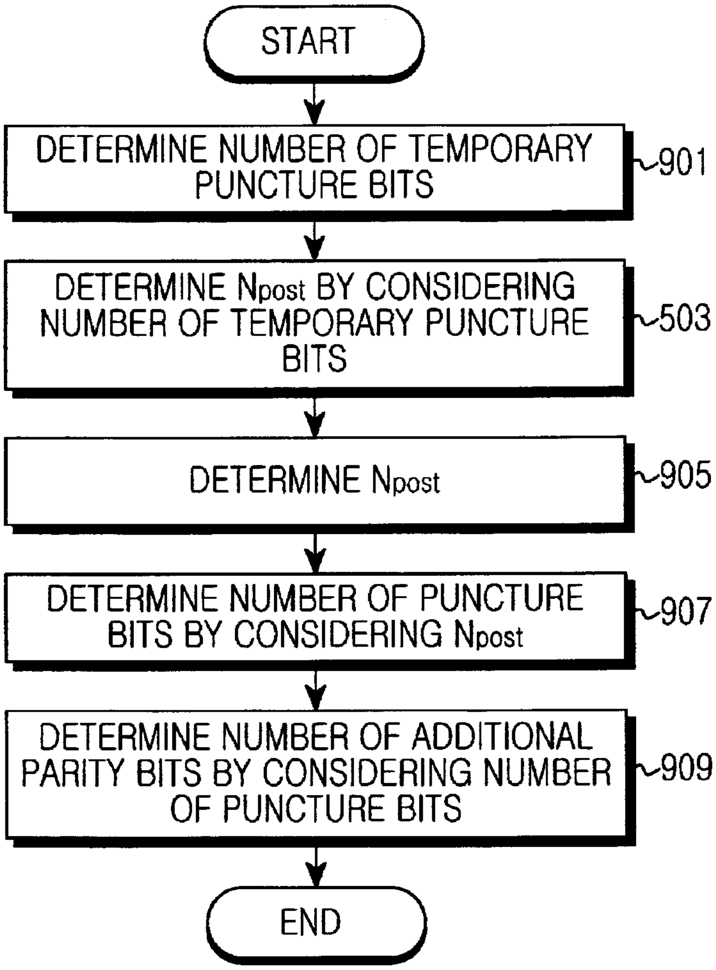
[Fig. 7]


START
CHECK SIGNALING TYPE
701
703
FIRST PARITY?
NO (SECOND PARITY)
YES
CHECK THE REQUIRED FER
705
CHECK VARIABLE FOR CROSS POINT OF THE REQUIRED FER
707
CHECK NUMBER OF PARITY BITS TO PUNCTURE USING VARIABLE
709
CHECK THE REQUIRED FER
713
CHECK VARIABLE FOR CROSS POINT OF THE REQUIRED FER
715
CHECK NUMBER OF PARITY BITS TO PUNCTURE USING VARIABLE
717
CHECK NUMBER OF ADDITIONAL PARITY BITS
719
SEND THE GENERATED PARITY
711
END

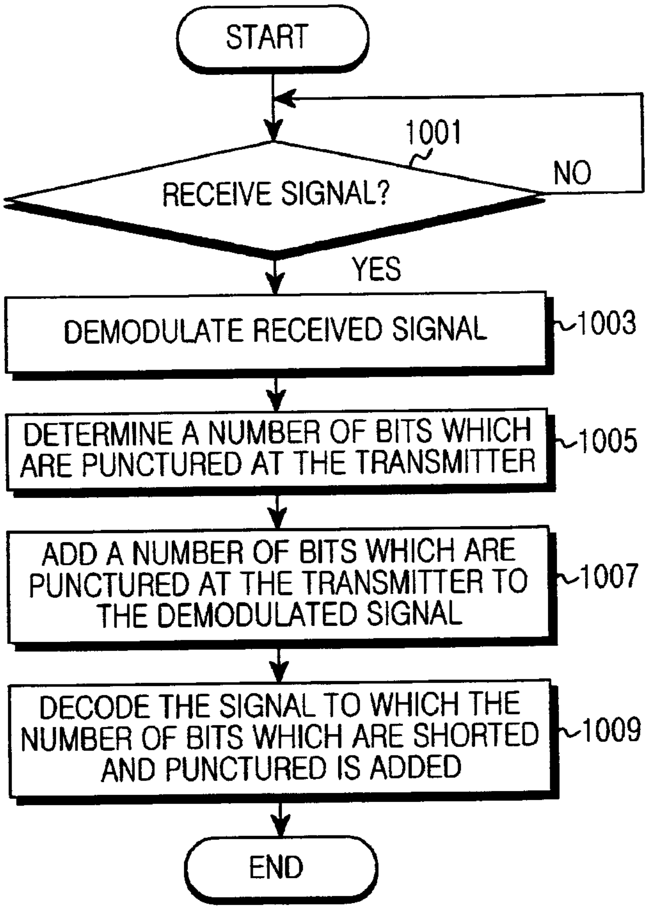
[Fig. 8]


START
DETERMINE NUMBER OF TEMPORARY PUNCTURE BITS
801
DETERMINE Npost BY CONSIDERING NUMBER OF TEMPORARY PUNCTURE BITS
803
DETERMINE Npost
805
DETERMINE NUMBER OF PUNCTURE BITS BY CONSIDERING Npost
807
END

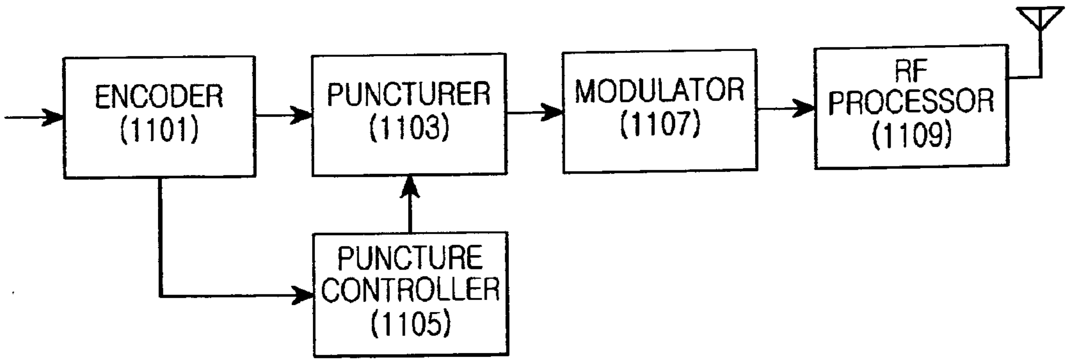
[Fig. 9]


START
DETERMINE NUMBER OF TEMPORARY PUNCTURE BITS
901
DETERMINE Npost BY CONSIDERING NUMBER OF TEMPORARY PUNCTURE BITS
503
DETERMINE Npost
905
DETERMINE NUMBER OF PUNCTURE BITS BY CONSIDERING Npost
907
DETERMINE NUMBER OF ADDITIONAL PARITY BITS BY CONSIDERING NUMBER OF PUNCTURE BITS
909
END

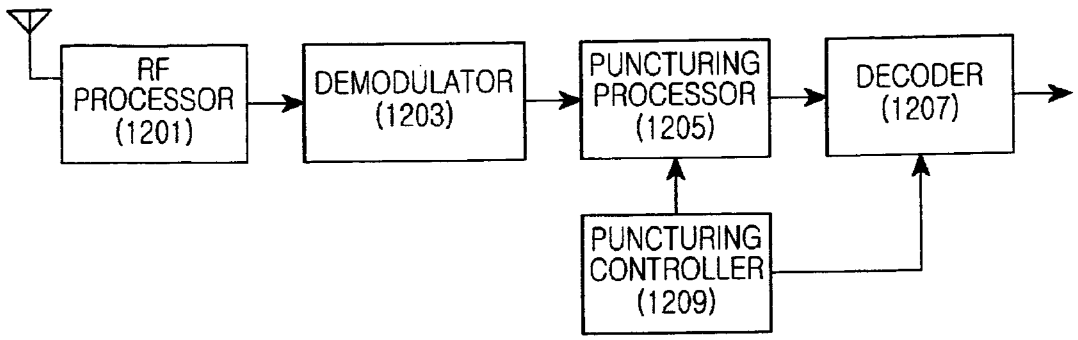
[Fig. 10]


START
RECEIVE SIGNAL?
1001
NO
YES
DEMODULATE RECEIVED SIGNAL
1003
DETERMINE A NUMBER OF BITS WHICH ARE PUNCTURED AT THE TRANSMITTER
1005
ADD A NUMBER OF BITS WHICH ARE PUNCTURED AT THE TRANSMITTER TO THE DEMODULATED SIGNAL
1007
DECODE THE SIGNAL TO WHICH THE NUMBER OF BITS WHICH ARE SHORTED AND PUNCTURED IS ADDED
1009
END

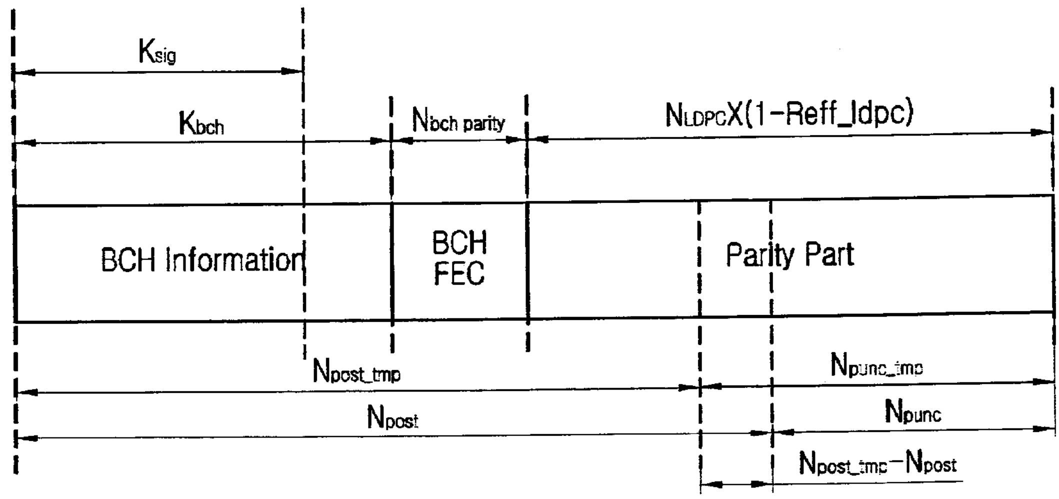
[Fig. 11]

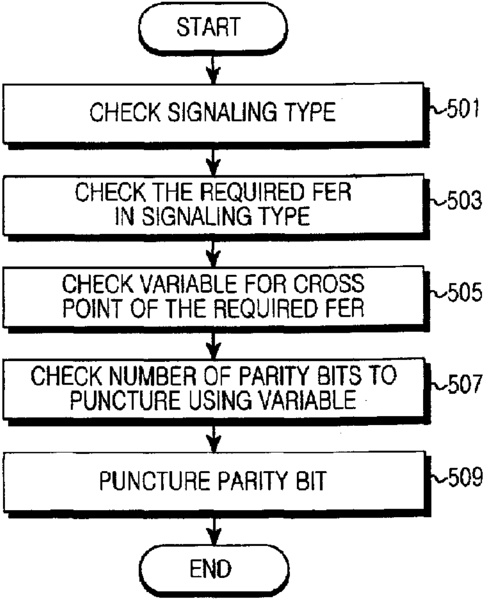

ENCODER (1101)
PUNCTURER (1103)
MODULATOR (1107)
RF PROCESSOR (1109)
PUNCTURE CONTROLLER (1105)

[Fig. 12]


RF PROCESSOR (1201)
DEMODULATOR (1203)
PUNCTURING PROCESSOR (1205)
DECODER (1207)
PUNCTURING CONTROLLER (1209)

[Fig. 13]


Ksig
Kbch
Nbch parity
NLDPCX(1-Reff_ldpc)
BCH Information
BCH FEC
Parity Part
Npost_tmp
Npunc_tmp
Npost
Npunc
Npost_tmp-Npost



START
CHECK SIGNALING TYPE
501
CHECK THE REQUIRED FER
IN SIGNALING TYPE
503
CHECK VARIABLE FOR CROSS
POINT OF THE REQUIRED FER
505
CHECK NUMBER OF PARITY BITS TO
PUNCTURE USING VARIABLE
507
PUNCTURE PARITY BIT
509
END