CLAIMS

1. A bit interleaving method for a communication system using quasi-cyclic low-density parity check codes, comprising:

a reception step of receiving a codeword of the quasi-cyclic low-density parity check codes made up of N cyclic blocks each including Q bits;

a bit permutation step of applying a bit permutation process to the codeword so as to permute the bits in the codeword; and

a division step of dividing the codeword, after the bit permutation process, into a plurality of constellation words, each of the constellation words being made up of M bits and indicating one of 2^M constellation points in a predetermined constellation, wherein

prior to the bit permutation process, the codeword is divided into $F \times N/M$ folding sections, F being an integer greater than one, each of the folding sections including M/F of the cyclic blocks, and each of the constellation words being associated with one of the $F \times N/M$ folding sections, and

in the bit permutation step, the bit permutation process is applied such that the M bits in each of the constellation words include F bits from each of M/F different cyclic blocks in a given folding section associated with a given constellation word, and such that all bits in the given folding section are mapped to only Q/F of the constellation words associated with the given folding section.

2. The bit interleaving method of Claim 1, wherein

the bit permutation step includes a folding section permutation step of independently applying a folding section permutation process to each of the $F \times N/M$ folding sections so as to permute the bits in each of the folding sections.

3. The bit interleaving method of Claim 2, wherein

in the folding section permutation step, the folding section permutation process

is performed such that the Q bits in a given cyclic block are each mapped to a bit of an identical robustness level in the Q/F constellation words associated with one of the folding sections that corresponds to the given cyclic block.

4. The bit interleaving method of Claim 1, wherein

F is equal to a number of bits of an identical robustness level in one of the constellation words .

5. The bit interleaving method of Claim 1, wherein

$F = 2$, and the constellation words are QAM constellations.

6. The bit interleaving method of Claim 2, wherein

the folding section permutation step includes a column-row permutation step of applying a column-row permutation process to the $M/F \times Q$ bits in each of the folding sections so as permute the $M/F \times Q$ bits.

7. The bit interleaving method of Claim 6, wherein

the column-row permutation process is equivalent to writing the $M/F \times Q$ bits row-wise into a matrix having Q columns and M/F rows, then reading the $M/F \times Q$ bits column-wise.

8. A bit deinterleaving method for deinterleaving a bit stream in a communication system using quasi-cyclic low-density parity check codes, comprising:

a reception step of receiving a bit sequence made up of $N \times Q$ bits; and

a reverse bit permutation step of applying a reverse bit permutation process to the received bit sequence so as to permute the bits in the bit sequence in order to restore the codeword of the quasi-cyclic low-density parity check codes, wherein

the reverse bit permutation process reverses the bit permutation process in the

bit interleaving method of Claim 1.

9. A bit interleaver for use in a communication system using quasi-cyclic low-density parity check codes, comprising:

a bit permutation unit receiving a codeword of the quasi-cyclic low-density parity check codes made up of N cyclic blocks each including Q bits, applying a bit permutation process to the codeword so as to permute the bits in the codeword, and dividing the codeword, for output after the bit permutation process, into a plurality of constellation words, each of the constellation words being made up of M bits and indicating one of 2^M constellation points in a predetermined constellation, wherein

prior to the bit permutation process, the codeword is divided into $F \times N/M$ folding sections, F being an integer greater than one, each of the folding sections including M/F of the cyclic blocks, and each of the constellation words being associated with one of the $F \times N/M$ folding sections, and

the bit permutation unit applies the bit permutation process such that the M bits in each of the constellation words include F bits from each of M/F different cyclic blocks in a given folding section associated with a given constellation word, and such that all bits in the given folding section are mapped to only Q/F of the constellation words associated with the given folding section.

10. The bit interleaver of Claim 9, wherein

the bit permutation unit includes a folding section permutation unit independently applying a folding section permutation process to each of the $F \times N/M$ folding sections so as to permute the bits in each of the folding sections.

11. The bit interleaver of Claim 10, wherein

the folding section permutation unit applies the folding section permutation process such that the Q bits in a given cyclic block are each mapped to a bit of an

identical robustness level in the Q/F constellation words associated with one of the folding sections that corresponds to the given cyclic block.

12. The bit interleaver of Claim 9, wherein

F is equal to a number of bits of an identical robustness level in one of the constellation words .

13. The bit interleaver of Claim 9, wherein

$F = 2$, and the constellation words are QAM constellations.

14. The bit interleaver of Claim 10, wherein

the folding section permutation unit applies a column-row permutation process to the $M/F \times Q$ bits in each of the folding sections so as permute the $M/F \times Q$ bits.

15. A bit deinterleaver for deinterleaving a bit stream in a communication system using quasi-cyclic low-density parity check codes, comprising

a reverse bit permutation unit receiving a bit sequence made up of $N \times Q$ bits, and applying a reverse bit permutation process to the received bit sequence so as to permute the bits in the bit sequence in order to restore a codeword of the quasi-cyclic low-density parity check codes , wherein

the reverse bit permutation process reverses the bit permutation process applied by the bit interleaver of Claim 9.

16. A decoder for use in a bit interleaving and demodulating system using quasi-cyclic low-density parity check codes, comprising:

a constellation demapper generating a soft bit sequence indicating a probability of a corresponding bit being one of a zero-bit and a one-bit;

the bit deinterleaver of Claim 15 deinterleaving the soft bit sequence; and

a low-density parity check decoder decoding the deinterleaved soft bit sequence.

17. The decoder of Claim 16, further comprising:

a subtraction unit subtracting input to the low-density parity check decoder from output of the low-density parity check decoder; and

the bit interleaver of Claim 9, providing the difference from the subtraction unit to the constellation demapper as feedback.

CLAIMS

1. A bit interleaving method for interleaving bits of a codeword generated based on a repeat-accumulate quasi-cyclic low-density parity check coding scheme, the codeword being generated by performing parity interleaving on a parity section, the bit interleaving method comprising:

a cyclic block permutation step of applying a cyclic block permutation process to a codeword made up of N cyclic blocks each consisting of Q bits, to reorder the cyclic blocks in accordance with a cyclic block permutation rule defining a reordering of the cyclic blocks;

a bit permutation step of applying a bit permutation process to the codeword after the cyclic block permutation process, to reorder the bits of the codeword in accordance with a bit permutation rule defining a reordering of the bits; and

a dividing step of dividing the codeword after the bit permutation process into a plurality of constellation words, each of the constellation words being made up of M bits, wherein

N is not a multiple of M,

the bit permutation rule defines the reordering of the bits of the codeword after the cyclic block permutation process, such that the Q bits in each of N'=N-X cyclic blocks are each allocated to a bit of an identical bit index in Q constellation words and the Q constellation words are each made up of one bit in each of M cyclic blocks, the M cyclic blocks being common to the Q constellation words, where X is a remainder of N divided by M, and

the bit index of the bit in each of the Q constellation words to which the bits in each of the N'=N-X cyclic blocks are each allocated is determined in accordance with the cyclic block permutation rule.

2. A bit interleaver for interleaving bits of a codeword generated based on a repeat-accumulate quasi-cyclic low-density parity check coding scheme, the codeword being generated by performing parity interleaving on a parity section, the bit interleaver comprising:

a cyclic block permutator applying a cyclic block permutation process to a codeword made up of N cyclic blocks each consisting of Q bits, to reorder the

cyclic blocks in accordance with a cyclic block permutation rule defining a reordering of the cyclic blocks; and

a bit permutator applying a bit permutation process to the codeword after the cyclic block permutation process, to reorder the bits of the codeword in accordance with a bit permutation rule defining a reordering of the bits; and

a divider dividing the codeword after the bit permutation process into a plurality of constellation words, each of the constellation words being made up of M bits, wherein

N is not a multiple of M,

the bit permutation rule defines the reordering of the bits of the codeword after the cyclic block permutation process, such that the Q bits in each of N'=N-X cyclic blocks are each allocated to a bit of an identical bit index in Q constellation words and the Q constellation words are each made up of one bit in each of M cyclic blocks, the M cyclic blocks being common to the Q constellation words, where X is a remainder of N divided by M, and

the bit index of the bit in each of the Q constellation words to which the bits in each of the N'=N-X cyclic blocks are each allocated is determined in accordance with the cyclic block permutation rule.

3. A signal processing method for processing a signal transmitted by modulating N×Q/M constellation words, the constellation words being generated by applying a bit reordering process to a codeword generated based on a repeat-accumulate quasi-cyclic low-density parity check coding scheme, and dividing bits of the codeword for each M bits, the codeword being made up of N cyclic blocks each including Q bits, the codeword being generated by performing parity interleaving on a parity section,

the bit reordering process comprising:

a cyclic block permutation process of reordering the cyclic blocks of the codeword in accordance with a cyclic block permutation rule defining a reordering of the cyclic blocks; and

a bit permutation process of reordering the bits of the codeword after the cyclic block permutation process in accordance with a bit permutation rule defining a reordering of the bits, wherein

N is not a multiple of M,

the bit permutation rule defines the reordering of the bits of the codeword

after the cyclic block permutation process, such that the Q bits in each of N'=N-X cyclic blocks are each allocated to a bit of an identical bit index in Q constellation words and the Q constellation words are each made up of one bit in each of M cyclic blocks, the M cyclic blocks being common to the Q constellation words, where X is a remainder of N divided by M, and

the bit index of the bit in each of the Q constellation words to which the bits in each of the N'=N-X cyclic blocks are each allocated is determined in accordance with the cyclic block permutation rule,

the signal processing method comprising:

a demodulating step of generating a demodulated signal by demodulating the signal, which has been transmitted by modulating the N×Q/M constellation words; and

a decoding step of decoding the demodulated signal in accordance with the cyclic block permutation rule and the bit permutation rule to generate data before coding according to the repeat-accumulate quasi-cyclic low-density parity check coding scheme.

4. A signal processor for processing a signal transmitted by modulating N×Q/M constellation words, the constellation words being generated by applying a bit reordering process to a codeword generated based on a repeat-accumulate quasi-cyclic low-density parity check coding scheme, and dividing bits of the codeword for each M bits, the codeword being made up of N cyclic blocks each including Q bits, the codeword being generated by performing parity interleaving on a parity section,

the bit reordering process comprising:

a cyclic block permutation process of reordering the cyclic blocks of the codeword in accordance with a cyclic block permutation rule defining a reordering of the cyclic blocks; and

a bit permutation process of reordering the bits of the codeword after the cyclic block permutation process in accordance with a bit permutation rule defining a reordering of the bits, wherein

N is not a multiple of M,

the bit permutation rule defines the reordering of the bits of the codeword after the cyclic block permutation process, such that the Q bits in each of N'=N-X cyclic blocks are each allocated to a bit of an identical bit index in Q constellation

words and the Q constellation words are each made up of one bit in each of M cyclic blocks, the M cyclic blocks being common to the Q constellation words, where X is a remainder of N divided by M, and

the bit index of the bit in each of the Q constellation words to which the bits in each of the N'=N-X cyclic blocks are each allocated is determined in accordance with the cyclic block permutation rule,

the signal processor comprising:

a demodulator generating a demodulated signal by demodulating the signal, which has been transmitted by modulating the N×Q/M constellation words; and

a decoder decoding the demodulated signal in accordance with the cyclic block permutation rule and the bit permutation rule to generate data before coding according to the repeat-accumulate quasi-cyclic low-density parity check coding scheme.