

# US Patent & Trademark Office

## Patent Public Search | Text View

United States Patent	12388469
Kind Code	B2
Date of Patent	August 12, 2025
Inventor(s)	Chen; Mengzhu et al.

### Rate matching method and apparatus for polar code

#### Abstract

Provided is a rate matching method and device for a Polar code. The method includes: concatenating K information bits and (N-K) frozen bits to generate a bit sequence of N bits, and encoding the bit sequence of N bits by means of a Polar code encoder with a generator matrix of size N×N to generate an initial bit sequence {S.sub.0, S.sub.1, . . . , S.sub.N-1} of N bits, where K and N are both positive integers and K is less than or equal to N; dividing a circular buffer into q parts, selecting bits from the initial bit sequence {S.sub.0, S.sub.1, . . . , S.sub.N-1} in a non-repeated manner, and writing the bits into the q parts of the circular buffer according to a predefined rule, where q=1, 2, 3 or 4; and sequentially selecting a bit sequence of a specified length from a predefined starting position in a bit sequence in the circular buffer and taking the bit sequence of the specified length as a bit sequence to be transmitted.

Inventors:	Chen; Mengzhu (Guangdong, CN), Xu; Jin (Guangdong, CN), Xu; Jun (Guangdong, CN)
Applicant:	ZTE Corporation (Guangdong, CN)
Family ID:	62831294
Assignee:	ZTE Corporation (Shenzhen, CN)
Appl. No.:	18/629536
Filed:	April 08, 2024

#### Prior Publication Data

Document Identifier	Publication Date
US 20240259035 A1	Aug. 01, 2024

#### Foreign Application Priority Data

CN	201710014289.6	Jan. 09, 2017
CN	201710056532.0	Jan. 25, 2017

#### Related U.S. Application Data

continuation parent-doc US 17664491 20220523 US 11955992 child-doc US 18629536  
continuation parent-doc US 16505688 20190708 US 11342945 20220524 child-doc US 17664491  
continuation parent-doc WO PCT/CN2018/071956 20180109 PENDING child-doc US 16505688

#### Publication Classification

Int. Cl.: H03M13/00 (20060101); H03M13/13 (20060101); H03M13/27 (20060101)  
U.S. Cl.:

**Field of Classification Search**

**CPC:** H03M (13/635); H03M (13/13); H03M (13/2792); H03M (13/6502); H03M (13/6591); H04L (1/0071); H04L (1/0057); H04L (1/0067); H04L (1/0041)

**USPC:** 714/776

**References Cited****U.S. PATENT DOCUMENTS**

<b>Patent No.</b>	<b>Issued Date</b>	<b>Patentee Name</b>	<b>U.S. Cl.</b>	<b>CPC</b>
8726121	12/2013	Malladi et al.	N/A	N/A
10341044	12/2018	Zhang et al.	N/A	N/A
10389484	12/2018	Kim et al.	N/A	N/A
2008/0301536	12/2007	Shin et al.	N/A	N/A
2015/0156242	12/2014	Hwang et al.	N/A	N/A
2016/0352464	12/2015	Shen	N/A	H04L 1/0067
2017/0005753	12/2016	Shen	N/A	H04L 1/1867
2017/0012739	12/2016	Shen	N/A	H03M 13/6306
2017/0012740	12/2016	Shen	N/A	H04L 1/0067
2018/0026663	12/2017	Wu et al.	N/A	N/A
2018/0034587	12/2017	Kim et al.	N/A	N/A
2019/0305887	12/2018	Jang et al.	N/A	N/A
2019/0312555	12/2018	Brindani et al.	N/A	N/A
2020/0083912	12/2019	Chen et al.	N/A	N/A
2020/0083987	12/2019	Xu et al.	N/A	N/A

**FOREIGN PATENT DOCUMENTS**

<b>Patent No.</b>	<b>Application Date</b>	<b>Country</b>	<b>CPC</b>
103023618	12/2012	CN	N/A
103746708	12/2013	CN	N/A
105811998	12/2015	CN	N/A
3 079 290	12/2015	EP	N/A
3 113 387	12/2016	EP	N/A
2019537290	12/2018	JP	N/A
10-2016-0096684	12/2015	KR	N/A
10-2016-0130471	12/2015	KR	N/A
2015143593	12/2014	WO	N/A

**OTHER PUBLICATIONS**

3GPP, Ericsson, "Considerations of CBRM and HARQ Operations," TSG-RAN WG1#49bis, R1-073030, Orlando, USA, Jun. 2007 (4 pages). cited by applicant

3GPP, ZTE, "Polar Codes Construction and Rate Matching Scheme," TSG RAN WG1 Meeting #89, R1-1707183, Hangzhou, China, May 2017 (13 pages). cited by applicant

Decision of Patent mailed on Apr. 6, 2021 for Japanese Patent Application No. 2019-537290, filed on Jan. 9, 2018 (4 pages). cited by applicant

Extended Search Report mailed on Aug. 6, 2020 for European Application No. 18736435.1, filed on Jan. 9, 2018 (11 pages). cited by applicant

Indian Office Action mailed Apr. 23, 2021 for Indian Patent Application No. 201937032233, filed on Jan. 9, 2018 (6 pages). cited by applicant

International Search Report and Written Opinion mailed on Mar. 28, 2018 for International Application No.

PCT/CN2018/071956, filed on Jan. 9, 2018 (11 pages). cited by applicant

Japanese Office Action mailed Nov. 4, 2020 for Japanese Patent Application No. 2019-537290, filed on Jan. 9, 2018 (8 pages). cited by applicant

Korean Office Action mailed May 20, 2020 for Korean Patent Application No. 10-2019-7023378, filed on Jan. 9, 2018 (8 pages). cited by applicant

Notice of Allowance mailed Jan. 18, 2021 for Korean Patent Application No. 10-2019-7023378, filed on Jan. 9, 2018 (6 pages). cited by applicant

Japanese Office Action mailed Apr. 20, 2022, for Japanese Patent Application No. 2021-078310, filed on Jan. 9, 2018

(17 pages). cited by applicant  
MediaTek Inc., “Examination of NR Coding Candidates for Low-Rate Applications”, 3GPP TSG RAN WG1 Meeting #86, Gothenburg, Sweden, R1-167871, 15 pages, Aug. 22-26, 2016. cited by applicant  
JPO, Decision of Patent for Japanese Application No. 2021-078310, mailed on Jun. 27, 2023, 4 pages. cited by applicant  
Niu, K. et al., “Beyond turbo codes: Rate-compatible punctured polar codes,” IEEE International Conference on Communications (ICC), 2013, pp. 3423-3427. cited by applicant  
EPO, Communication pursuant to Article 94(3) EPC for European Application No. 18736435.1, mailed on Aug. 25, 2023, 6 pages. cited by applicant  
EPO, Invention to grant for European Application No. 18736435.1, mailed on Mar. 27, 2024, 5 pages. cited by applicant  
Extended European Search Report for European Application No. 24185277.1, dated Jan. 16, 2025, 10 pages. cited by applicant

---

*Primary Examiner:* Kerveros; James C

*Attorney, Agent or Firm:* Perkins Coie LLP

---

## Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS (1) This patent document is a continuation of and claims priority to U.S. patent application Ser. No. 17/664,491, filed on May 23, 2022, which is a continuation of U.S. patent application Ser. No. 16/505,688, filed on Jul. 8, 2019, now U.S. Pat. No. 11,342,945, which is a continuation of and claims priority to International Patent Application No. PCT/CN2018/071956, filed on Jan. 9, 2018, which claims the benefit of priority of Chinese Patent Application No. 201710014289.6, filed on Jan. 9, 2017, and Chinese Patent Application No. 201710056532.0, filed on Jan. 25, 2017. The entire contents of the before-mentioned patent applications are incorporated by reference as part of the disclosure of this application.

## TECHNICAL FIELD

(1) The present disclosure relates to the field of communications and, for example, to a rate matching method and device for a Polar code.

## BACKGROUND

(2) In the related art, Polar code is a rigorously proven constructive code capable of reaching a channel capacity and satisfying requirements of the fifth generation radio access technology (5G RAT) for the throughput and latency in the communication. A codeword obtained from the Polar encoding may be expressed as  $x = u \cdot G$ , where  $u = (u_1, \dots, u_N)$  consists of information bits and frozen bits. The information bits may include one or more check bits. The check bits may be generated through parity check encoding, cyclic redundancy check encoding, RS encoding and the like. The frozen bits are known bits in the encoding, and generally are 0 or pseudo-random bits.

(3) The structure of the Polar encoder of length  $N$  may be obtained by a recursion of two encoder of length  $N/2$ . FIG. 1a and FIG. 1b are schematic diagrams of a recursive structure of a Polar code in the related art. FIG. 2 is a structural diagram of a basic unit of a recursive encoder structure of a Polar code in the related art. As shown in FIG. 1a, FIG. 1b and FIG. 2, a unit ( $N=2$ ) of a recursive structure is the basic unit shown in FIG. 2.

(4) The length  $N$  of a data bit sequence obtained from the Polar encoding is a power of 2 and unnecessary bits can be discarded in a puncturing or shortening manner to perform rate matching for the transmission of any code length. Different code lengths and code rates correspond to different rate matching patterns. Therefore, different hardware modules are needed to implement the rate matching, thereby resulting in high complexity of Polar code hardware in different application scenarios.

(5) No effective solution has been proposed for the problem in the related art of high complexity of Polar code hardware for transmitting a bit sequence of any length.

## SUMMARY

(6) The present disclosure provides a rate matching method and device for a Polar code to solve at least the problem in the related art of high complexity of Polar code hardware for transmitting a bit sequence of any length.

(7) The present disclosure provides a rate matching method for a Polar code, including:  $K$  information bits and  $(N-K)$  frozen bits are concatenated to generate a bit sequence of  $N$  bits, and the bit sequence of  $N$  bits is encoded by means of a Polar code encoder with a generator matrix of size  $N \times N$  to generate an initial bit sequence  $\{S_0, S_1, \dots, S_{N-1}\}$  of  $N$  bits, wherein  $K$  and  $N$  are both positive integers and  $K$  is less than or equal to  $N$ .

(8) A circular buffer is divided into  $q$  parts, bits are selected from the initial bit sequence  $\{S_0, S_1, \dots, S_{N-1}\}$  in a non-repeated manner, and the bits are written into the  $q$  parts of the circular buffer according to a predefined rule, where  $q=1, 2, 3$  or  $4$ .

(9) A bit sequence of a specified length is sequentially selected from a predefined starting position in a bit sequence in the circular buffer, and the bit sequence of the specified length is taken as a bit sequence to be transmitted.

(10) In some embodiments, the  $K$  information bits may include check bits.

(11) In some embodiments, the predefined rule is determined by a one-to-one mapping interleaving function  $f(n)$  generated according to a data characteristic of the Polar code, where  $n=0, 1, \dots, N-1$ ,  $f(n)=0, 1, \dots, N-1$ ,  $n$  is a bit position index in the initial bit sequence, and  $f(n)$  is a position index in the circular buffer; and selecting the bits from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in the non-repeated manner and writing the bits into the  $q$  parts of the circular buffer according to the predefined rule includes: mapping a bit  $S_{\text{sub}.n}$  with a bit position index  $n$  in the initial bit sequence onto a position with a position index  $f(n)$  in the circular buffer according to the one-to-one mapping interleaving function  $f(n)$ .

(12) It is to be noted that since a mapping  $\{n\} \xrightarrow{\text{fwdarw.}} \{f(n)\}$  is a one-to-one mapping, an inverse function  $p(n)$  of  $f(n)$ , which satisfies a mapping  $\{p(n)\} \xrightarrow{\text{fwdarw.}} \{n\}$ , exists. That is, the predefined rule may be determined by a one-to-one mapping interleaving function  $p(n)$  generated according to the data characteristic of the Polar code, where  $n=0, 1, \dots, N-1$ ,  $p(n)=0, 1, \dots, N-1$ ,  $p(n)$  is a bit position index in the initial bit sequence, and  $n$  is a position index in the circular buffer. Selecting the bits from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in the non-repeated manner and writing the bits into the  $q$  parts of the circular buffer according to the predefined rule includes: mapping a bit  $S_{\text{sub}.p(n)}$  with a bit position index  $p(n)$  in the initial bit sequence onto a position with a position index  $n$  in the circular buffer according to the one-to-one mapping interleaving function  $p(n)$ .

(13) In some embodiments, the one-to-one mapping interleaving function  $f(n)$  has the following nesting characteristic: a mapping  $\{n_{\text{sub}.0}\} \xrightarrow{\text{fwdarw.}} \{f(n_{\text{sub}.0})\}$  may be obtained by deleting an element greater than  $N_{\text{sub}.0}$  from a sequence  $\{n\}$  and a sequence  $\{f(n)\}$  in a mapping  $\{n\} \xrightarrow{\text{fwdarw.}} \{f(n)\}$  of the one-to-one mapping interleaving function, where  $n_{\text{sub}.0}=0, 1, 2, \dots, N_{\text{sub}.0}-1$  and  $N_{\text{sub}.0}$  is a positive integer less than or equal to  $N$ .

(14) In some embodiments, selecting the bits from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in the non-repeated manner and writing the bits into the  $q$  parts of the circular buffer according to the predefined rule includes: mapping a bit  $S_{\text{sub}.n}$  with a bit position index  $n$  in the initial bit sequence onto a position with a position index  $\text{mod}(f(n)+m, N)$  in the circular buffer, wherein  $m=0, 1, \dots, N-1$ ,  $m$  is an offset and  $\text{mod}(x_1, x_2)$  represents a remainder of a division  $x_1/x_2$ , where  $x_1$  is an integer and  $x_2$  is a positive integer.

(15) In some embodiments, the data characteristic includes at least one of: a transport block length, a code rate, a number of available physical resource blocks, a modulation and coding level, a user equipment type index and a data transmission link direction.

(16) In some embodiments, the predefined starting position includes one of the following:

(17) A starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(18) A position of  $P_{\text{sub}.0}=M-1$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents a position index of the bit sequence in the circular buffer and  $M$  is a length of the bit sequence to be transmitted.

(19) A position of  $P_{\text{sub}.0}=N-M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the sequence to be transmitted, and  $N$  is a length of the initial bit sequence.

(20) An ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(21) In some embodiments, the predefined starting position is determined by a code rate of the Polar encoding.

(22) In some embodiments, the predefined starting position may be selected in the following manner:

(23) When the code rate of the Polar encoding is less than or equal to a predefined threshold, the position of  $P_{\text{sub}.0}=N-M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is the length of the initial bit sequence.

(24) It is to be noted that since the predefined starting position is selected according to the code rate of the Polar encoding, when the code rate of the Polar encoding is greater than the predefined threshold, the predefined starting position is determined by one of the following manners:

(25) The starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(26) The position of  $P_{\text{sub}.0}=M-1$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer and  $M$  is the length of the bit sequence to be transmitted.

(27) The ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(28) When the circular buffer is composed of a sixth part, a seventh part, an eighth part and a ninth part arranged sequentially, a starting bit position of the seventh part of the bit sequence in the circular buffer is taken as the predefined starting position.

(29) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, an ending bit position of the eighth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(30) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, a starting bit position of the eighth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(31) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, a starting bit position of the ninth part of the bit sequence in the circular buffer is taken as the predefined

starting position.

(32) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, if  $M \leq t_{\text{sub}.8} + t_{\text{sub}.9}$ , a position of  $P_{\text{sub}.0} = t_{\text{sub}.6} + t_{\text{sub}.7} + M - 1$  is taken as the predefined starting position; if  $M > t_{\text{sub}.8} + t_{\text{sub}.9}$ , a position of  $P_{\text{sub}.0} = M - 1 - t_{\text{sub}.8} - t_{\text{sub}.9}$  is taken as the predefined starting position, where  $M$  is the length of the bit sequence to be transmitted,  $t_{\text{sub}.6}$  is a length in bits of the sixth part,  $t_{\text{sub}.7}$  is a length in bits of the seventh part,  $t_{\text{sub}.8}$  is a length in bits of the eighth part, and  $t_{\text{sub}.9}$  is a length in bits of the ninth part.

(33) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, an ending bit position of the sixth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(34) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, if  $M \leq t_{\text{sub}.8} + t_{\text{sub}.9}$ , a position of  $P_{\text{sub}.0} = t_{\text{sub}.8} + t_{\text{sub}.9} - M$  is taken as the predefined starting position; if  $M > t_{\text{sub}.8} + t_{\text{sub}.9}$ , a position of  $P_{\text{sub}.0} = N + t_{\text{sub}.8} + t_{\text{sub}.9} - M$  is taken as the predefined starting position, where  $M$  is the length of the bit sequence to be transmitted,  $t_{\text{sub}.6}$  is the length in bits of the sixth part,  $t_{\text{sub}.7}$  is the length in bits of the seventh part,  $t_{\text{sub}.8}$  is the length in bits of the eighth part, and  $t_{\text{sub}.9}$  is the length in bits of the ninth part.

(35) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, the starting bit position of the ninth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(36) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, an ending bit position of the seventh part of the bit sequence in the circular buffer is taken as the predefined starting position.

(37) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, the ending bit position of the sixth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(38) In some embodiments, the predefined starting position may be determined by the following manner:

(39) When the code rate of the Polar encoding is greater than the predefined threshold, the starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(40) In some embodiments, a mother code of the Polar code has a length of  $N = 2^{\lceil \log_2(K/R) \rceil + m}$ , wherein  $\lceil \cdot \rceil$  represents a ceiling operation,  $R$  is a code rate and  $m$  is a positive integer.

(41) In some embodiments, the bit sequence in the circular buffer is obtained by performing bit reversal order (BRO) interleaving on the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$ , and a bit  $S_{\text{sub}.n}$  with a bit position index  $n$  in the initial bit sequence is mapped onto a position with a position index  $\text{mod}(\text{BRO}(n) + m, N)$  in the circular buffer by means of a BRO interleaver, where  $n = 0, 1, \dots, N-1$ ,  $m = 0, 1, \dots, N-1$ ,  $m$  is an offset and  $\text{mod}(x_1, x_2)$  represents a remainder of a division  $x_1/x_2$ .

(42) In some embodiments, the bit sequence in the circular buffer is obtained by performing bit reversal order (BRO) interleaving on the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$ , and a bit  $S_n$  with a bit position index  $n$  in the initial bit sequence is mapped onto a position with a position index  $N - 1 - \text{mod}(\text{BRO}(n) + m, N)$  in the circular buffer by means of a BRO interleaver, where  $n = 0, 1, \dots, N-1$ ,  $m = 0, 1, \dots, N-1$ ,  $m$  is an offset and  $\text{mod}(x_1, x_2)$  represents a remainder of a division  $x_1/x_2$ .

(43) In some embodiments, sequentially selecting the bit sequence of the specified length from the predefined starting position in the bit sequence in the circular buffer and taking the bit sequence of the specified length as the bit sequence to be transmitted includes:

(44) Bits are sequentially selected in an ascending or descending order of indexes from a predefined position in the bit sequence in the circular buffer, when reaching to an end of the bit sequence in the circular buffer, the selecting is continued from an other end of the bit sequence in the circular buffer until the bit sequence of the specified length is selected, and the bit sequence of the specified length is taken as the bit sequence to be transmitted.

(45) In some embodiments, when a code rate of the Polar encoding is less than or equal to a predefined threshold, a position of  $P_{\text{sub}.0} = N - M$  in the circular buffer is taken as the predefined starting position and  $M$  bits are sequentially selected in an ascending order of indexes; when the selecting goes to an end of the bit sequence in the circular buffer, the selecting is continued from an other end of the bit sequence in the circular buffer, where  $P_{\text{sub}.0}$  represents a position index of the bit sequence in the circular buffer,  $M$  is a length of the bit sequence to be transmitted, and  $N$  is a length of the initial bit sequence.

(46) In some embodiments, when a code rate of the Polar encoding is greater than a predefined threshold, a starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position and  $M$  bits are sequentially selected in an ascending order of indexes; when the reading goes to an end of the bit sequence in the circular buffer, the reading is continued from an other end of the bit sequence in the circular buffer, wherein  $N$  is a length of the initial bit sequence.

(47) In some embodiments, the bit sequence to be transmitted is arranged in a same order or in a reverse order of the bit sequence of the specified length read from the circular buffer.

(48) The present disclosure further provides a rate matching device for a Polar code, including a generation module, a writing module, a selecting module and a determination module. The generation module is configured to concatenate  $K$  information bits and  $(N - K)$  frozen bits to generate a bit sequence of  $N$  bits, and encode the bit sequence of  $N$  bits by

means of a Polar code encoder with a generator matrix of size  $N \times N$  to generate an initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  of  $N$  bits, where  $K$  and  $N$  are both positive integers and  $K$  is less than or equal to  $N$ . The writing module is configured to divide a circular buffer into  $q$  parts, select bits from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in a non-repeated manner, and write the bits into the  $q$  parts of the circular buffer according to a predefined rule, wherein  $q=1, 2, 3$  or  $4$ . The selecting module is configured to sequentially select a bit sequence of a specified length from a predefined starting position in a bit sequence in the circular buffer. The determination module is configured to take the bit sequence of the specified length as a bit sequence to be transmitted.

(49) In some embodiments, the predefined rule is determined by a one-to-one mapping interleaving function  $f(n)$  generated according to a data characteristic of the Polar code, wherein  $n=0, 1, \dots, N-1$ ,  $f(n)=0, 1, \dots, N-1$ ,  $n$  is a bit position index in the initial bit sequence, and  $f(n)$  is a position index in the circular buffer. The writing module is configured to map a bit  $S_n$  with a bit position index  $n$  in the initial bit sequence onto a position with a position index  $f(n)$  in the circular buffer according to the one-to-one mapping interleaving function  $f(n)$ .

(50) It is to be noted that since a mapping  $\{n\} \rightarrow \{f(n)\}$  is a one-to-one mapping, an inverse function  $p(n)$  of  $f(n)$ , which satisfies a mapping  $\{p(n)\} \rightarrow \{n\}$ , exists. That is, the predefined rule may be determined by a one-to-one mapping interleaving function  $p(n)$  generated according to the data characteristic of the Polar code, where  $n=0, 1, \dots, N-1$ ,  $p(n)=0, 1, \dots, N-1$ ,  $p(n)$  is a bit position index in the initial bit sequence, and  $n$  is a position index in the circular buffer. Selecting the bits from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in the non-repeated manner and writing the bits into the  $q$  parts of the circular buffer according to the predefined rule includes: mapping a bit  $S_{\text{sub}.p(n)}$  with a bit position index  $p(n)$  in the initial bit sequence onto a position with a position index  $n$  in the circular buffer according to the one-to-one mapping interleaving function  $p(n)$ .

(51) In some embodiments, the one-to-one mapping interleaving function  $f(n)$  has the following nesting characteristic: a mapping  $\{n_{\text{sub}.0}\} \rightarrow \{f(n_{\text{sub}.0})\}$  may be obtained by deleting an element greater than  $N_{\text{sub}.0}$  from a sequence  $\{n\}$  and a sequence  $\{f(n)\}$  in a mapping  $\{n\} \rightarrow \{f(n)\}$  of the one-to-one mapping interleaving function, where  $n_{\text{sub}.0}=0, 1, 2, \dots, N_{\text{sub}.0}-1$  and  $N_{\text{sub}.0}$  is a positive integer less than or equal to  $N$ .

(52) In some embodiments, the predefined rule for the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  may be performed by mapping the bit  $S_{\text{sub}.n}$  with the bit position index  $n$  in the initial bit sequence onto a position with a position index  $\text{mod}(f(n)+m, N)$  in the circular buffer according to the data characteristic of the Polar code, where  $m=0, 1, \dots, N-1$ ,  $m$  is an offset and  $\text{mod}(x_{\text{sub}.1}, x_{\text{sub}.2})$  represents a remainder of a division  $x_{\text{sub}.1}/x_{\text{sub}.2}$ , where  $x_{\text{sub}.1}$  is an integer and  $x_{\text{sub}.2}$  is a positive integer.

(53) In some embodiments, the predefined starting position is selected in one of the following manners:

(54) A starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(55) A position of  $P_{\text{sub}.0}=M-1$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents a position index of the bit sequence in the circular buffer and  $M$  is a length of the bit sequence to be transmitted.

(56) A position of  $P_{\text{sub}.0}=N-M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is a length of the initial bit sequence.

(57) An ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(58) The present disclosure further provides a rate matching device for a Polar code, including: a processor and a memory. The processor is configured to perform the following operations:  $K$  information bits and  $(N-K)$  frozen bits are concatenated to generate a bit sequence of  $N$  bits, and the bit sequence of  $N$  bits is encoded by means of a Polar code encoder with a generator matrix of size  $N \times N$  to generate an initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  of  $N$  bits, where  $K$  and  $N$  are both positive integers and  $K$  is less than or equal to  $N$ ; a circular buffer is divided into  $q$  parts, bits are selected from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in a non-repeated manner, and the bits are written into the  $q$  parts of the circular buffer according to a predefined rule, where  $q=1, 2, 3$  or  $4$ ; and a bit sequence of a specified length is sequentially selected from a predefined starting position in a bit sequence in the circular buffer and the bit sequence of the specified length is taken as a bit sequence to be transmitted.

(59) In some embodiments, the processor is further configured to perform, according to the instructions stored in the memory, the following operations: the predefined rule for the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  is determined by a one-to-one mapping interleaving function  $f(n)$  generated according to a data characteristic of the Polar code, where  $n=0, 1, \dots, N-1$ ,  $f(n)=0, 1, \dots, N-1$ ,  $n$  is a bit position index in the initial bit sequence, and  $f(n)$  is a position index in the circular buffer; and a bit  $S_n$  with a bit position index  $n$  in the initial bit sequence is mapped onto a position with a position index  $f(n)$  in the circular buffer according to the one-to-one mapping interleaving function  $f(n)$ .

(60) Since a mapping  $\{n\} \rightarrow \{f(n)\}$  is a one-to-one mapping, an inverse function  $p(n)$  of  $f(n)$ , which satisfies a mapping  $\{p(n)\} \rightarrow \{n\}$ , exists. That is, the predefined rule may be determined by a one-to-one mapping interleaving function  $p(n)$  generated according to the data characteristic of the Polar code, where  $n=0, 1, \dots, N-1$ ,  $p(n)=0, 1, \dots, N-1$ ,  $p(n)$  is a bit position index in the initial bit sequence, and  $n$  is a position index in the circular buffer. The operation of selecting the bits from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in the non-repeated manner and writing the bits into the  $q$  parts of the circular buffer according to the predefined rule includes: mapping a bit  $S_{\text{sub}.p(n)}$  with a bit position index  $p(n)$  in the initial bit sequence onto a position with a position index  $n$  in the circular buffer according to the one-to-one mapping interleaving function  $p(n)$ .

- (61) In some embodiments, the predefined starting position is selected in one of the following manners:
- (62) A starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.
- (63) A position of  $P_{\text{sub}.0}=M-1$  in the circular buffer is taken as the predefined starting position, wherein  $P_{\text{sub}.0}$  represents a position index of the bit sequence in the circular buffer and  $M$  is a length of the bit sequence to be transmitted.
- (64) A position of  $P_{\text{sub}.0}=N-M$  in the circular buffer is taken as the predefined starting position, wherein  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is a length of the initial bit sequence.
- (65) An ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position.
- (66) The present disclosure further provides a computer storage medium, which is configured to store executive instructions for executing any rate matching method for the Polar code in the embodiments described above.
- (67) The rate matching method and device for the Polar code provided by the present disclosure can solve the problem that Polar code hardware has high complexity and has a complicated encoding process in a hybrid automatic repeat request mechanism, significantly reducing the complexity of Polar code hardware and simplifying the encoding process in the hybrid automatic repeat request mechanism.
- 

## Description

### BRIEF DESCRIPTION OF DRAWINGS

- (1) FIG. 1a is a schematic diagram of a recursive encoding structure of a Polar code in the related art;
- (2) FIG. 1b is a schematic diagram of another recursive encoding structure of a Polar code in the related art;
- (3) FIG. 2 is a structural diagram of a basic unit of a recursive encoding structure of a Polar code in the related art;
- (4) FIG. 3 is a flowchart of a rate matching method for a Polar rate according to an embodiment;
- (5) FIG. 4 is a block diagram of a rate matching device for a Polar rate according to an embodiment; and
- (6) FIG. 5 is a block diagram of another rate matching device for a Polar rate according to an embodiment.

### DETAILED DESCRIPTION

(7) The terms “first”, “second” and the like in the description, claims and above drawings of the present application are used to distinguish between similar objects and are not necessarily used to describe a particular order or sequence. It should be understood that the data used in this way is interchangeable when appropriate so that embodiments of the present disclosure described herein can also be implemented in a sequence not illustrated or described herein. In addition, the terms “comprising”, “including” or any other variations thereof described herein are intended to encompass a non-exclusive inclusion. For example, a process, method, system, product or device that includes a series of steps or elements not only includes the expressly listed steps or elements but may also include other steps or elements that are not expressly listed or are inherent to such a process, method, system, product or device.

#### Embodiment 1

(8) A rate matching method for a Polar code is provided in this embodiment. The steps illustrated in the flowcharts in the accompanying drawings may be performed by a computer system such as a group of instructions executable to a computer. Although logical sequences are illustrated in the flowcharts, the illustrated or described steps may be performed in sequences different from those described herein in some cases.

(9) In the above operating environment, the present disclosure provides the rate matching method for the Polar code shown in FIG. 3. FIG. 3 is a flowchart of a rate matching method for a Polar code according to this embodiment. As shown in FIG. 3, the method includes:

(10) In 302,  $K$  information bits and  $(N-K)$  frozen bits are concatenated to generate a bit sequence of  $N$  bits, and the bit sequence of  $N$  bits is encoded by means of a Polar code encoder with a generator matrix of size  $N \times N$  to generate an initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  of  $N$  bits, where  $K$  and  $N$  are both positive integers and  $K$  is less than or equal to  $N$ .

(11) The  $K$  information bits may be mapped onto a bit channel and may include a check bit.

(12) In 304, a circular buffer is divided into  $q$  parts, bits are selected from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in a non-repeated manner, and the bits are written into the  $q$  parts of the circular buffer according to a predefined rule, where  $q=1, 2, 3$  or  $4$ .

(13) In 306, a bit sequence of a specified length is sequentially selected from a predefined starting position in a bit sequence in the circular buffer and the bit sequence of the specified length is taken as a bit sequence to be transmitted.

(14) In the above steps, a bit sequence is encoded by Polar encoder, a bit sequence after Polar encoding is processed according to a predefined rule to obtain the bit sequence in the circular buffer, and a bit sequence of a specified length is sequentially selected from a predefined starting position and taken as the bit sequence to be transmitted. In this way, proper processing and selecting rules are used to adapt to the transmission of data in different scenarios, thereby solving the problem in the related art that Polar code hardware has high complexity and has a complicated encoding process in a hybrid automatic repeat request mechanism, significantly reducing the complexity of Polar code hardware and simplifying the encoding process.

(15) The circular buffer here may be a hardware circular buffer, and may also be a virtual device, which is not limited in

this embodiment.

(16) In some embodiments, a mother code of the Polar code has a length of  $N=2^{\lceil \log_2(K/R) \rceil / (1+\Delta)}$ , where  $\lceil \cdot \rceil$  represents a ceiling operation,  $0 \leq \Delta < 2$ , and  $R$  is a code rate for the Polar encoding.

(17) In some embodiments, the predefined rule for the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  is determined by a one-to-one mapping interleaving function  $f(n)$  generated according to a data characteristic of the Polar code, where  $n=0, 1, \dots, N-1$ ,  $f(n)=0, 1, \dots, N-1$ ,  $n$  is a bit position index in the initial bit sequence, and  $f(n)$  is a position index in the circular buffer; and a bit  $S_n$  with a bit position index  $n$  in the initial bit sequence is mapped onto a position with a position index  $f(n)$  in the circular buffer according to the one-to-one mapping interleaving function.

(18) In some embodiments, the one-to-one mapping interleaving function  $f(n)$  has the following nesting characteristic: a mapping  $\{n\}_{\text{sub}.0} \rightarrow \{f(n_{\text{sub}.0})\}$  may be directly obtained by deleting an element greater than  $N_{\text{sub}.0}$  from a sequence  $\{n\}$  and a sequence  $\{f(n)\}$  in a mapping  $\{n\} \rightarrow \{f(n)\}$  of the one-to-one mapping interleaving function, where  $n_{\text{sub}.0}=0, 1, 2, \dots, N_{\text{sub}.0}-1$  and  $N_{\text{sub}.0}$  is a positive integer less than or equal to  $N$ .

(19) Since the mapping  $\{n\} \rightarrow \{f(n)\}$  is a one-to-one mapping, an inverse function  $p(n)$  of  $f(n)$ , which satisfies a mapping  $\{p(n)\} \rightarrow \{n\}$ , exists. That is, the predefined rule may be determined by a one-to-one mapping interleaving function  $p(n)$  generated according to the data characteristic of the Polar code, where  $n=0, 1, \dots, N-1$ ,  $p(n)=0, 1, \dots, N-1$ ,  $p(n)$  is a bit position index in the initial bit sequence, and  $n$  is a position index in the circular buffer. The step of selecting the bits from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in the non-repeated manner and writing the bits into the  $q$  parts of the circular buffer according to the predefined rule includes: mapping a bit  $S_{\text{sub}.p(n)}$  with a bit position index  $p(n)$  in the initial bit sequence onto a position with a position index  $n$  in the circular buffer according to the one-to-one mapping interleaving function  $p(n)$ .

(20) In some embodiments, the predefined rule for the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  may be performed by mapping the bit  $S_{\text{sub}.n}$  with the bit position index  $n$  in the initial bit sequence onto a position with a position index  $\text{mod}(f(n)+m, N)$  in the circular buffer according to the data characteristic of the Polar code, where  $m=0, 1, \dots, N-1$ ,  $m$  is an offset and  $\text{mod}(x_{\text{sub}.1}, x_{\text{sub}.2})$  represents a remainder of a division  $x_{\text{sub}.1}/x_{\text{sub}.2}$ , where  $x_{\text{sub}.1}$  is an integer and  $x_{\text{sub}.2}$  is a positive integer.

(21) In some embodiments, the data characteristic includes at least one of: a transport block length, a code rate, a number of available physical resource blocks, a modulation and coding level, a user equipment type index and a data transmission link direction.

(22) In some embodiments, the predefined starting position is selected in one of the following manners:

(23) A starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(24) A position of  $P_{\text{sub}.0}=M-1$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents a position index of the bit sequence in the circular buffer and  $M$  is a length of the bit sequence to be transmitted.

(25) A position of  $P_{\text{sub}.0}=N-M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is a length of the initial bit sequence.

(26) An ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(27) In some embodiments, the predefined starting position is determined by a code rate of the Polar encoding.

(28) In some embodiments, the predefined starting position may be selected in the following manner:

(29) When the code rate of the Polar encoding is less than or equal to a predefined threshold, the position of  $P_{\text{sub}.0}=N-M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is the length of the initial bit sequence.

(30) It is to be noted that since the predefined starting position is determined by the code rate of the Polar encoding, when the code rate of the Polar encoding is greater than the predefined threshold, the predefined starting position is selected in one of the following manners:

(31) The starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(32) The position of  $P_{\text{sub}.0}=M-1$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer and  $M$  is the length of the bit sequence to be transmitted.

(33) The ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(34) When the circular buffer is composed of a sixth part, a seventh part, an eighth part and a ninth part arranged sequentially, a starting bit position of the seventh part of the bit sequence in the circular buffer is taken as the predefined starting position.

(35) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, an ending bit position of the eighth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(36) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, a starting bit position of the eighth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(37) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged



sequentially, a starting bit position of the ninth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(38) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, if  $M \leq t_{\text{sub}.8} + t_{\text{sub}.9}$ , a position of  $P_{\text{sub}.0} = t_{\text{sub}.6} + t_{\text{sub}.7} + M - 1$  is taken as the predefined starting position; if  $M > t_{\text{sub}.8} + t_{\text{sub}.9}$ , a position of  $P_{\text{sub}.0} = M - 1 - t_{\text{sub}.8} - t_{\text{sub}.9}$  is taken as the predefined starting position, where  $M$  is the length of the bit sequence to be transmitted,  $t_{\text{sub}.6}$  is a length in bits of the sixth part,  $t_{\text{sub}.7}$  is a length in bits of the seventh part,  $t_{\text{sub}.8}$  is a length in bits of the eighth part, and  $t_{\text{sub}.9}$  is a length in bits of the ninth part.

(39) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, an ending bit position of the sixth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(40) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, if  $M \leq t_{\text{sub}.8} + t_{\text{sub}.9}$ , a position of  $P_{\text{sub}.0} = t_{\text{sub}.8} + t_{\text{sub}.9} - M$  is taken as the predefined starting position; if  $M > t_{\text{sub}.8} + t_{\text{sub}.9}$ , a position of  $P_{\text{sub}.0} = N + t_{\text{sub}.8} + t_{\text{sub}.9} - M$  is taken as the predefined starting position, where  $M$  is the length of the bit sequence to be transmitted,  $t_{\text{sub}.6}$  is the length in bits of the sixth part,  $t_{\text{sub}.7}$  is the length in bits of the seventh part,  $t_{\text{sub}.8}$  is the length in bits of the eighth part, and  $t_{\text{sub}.9}$  is the length in bits of the ninth part.

(41) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, the starting bit position of the ninth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(42) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, an ending bit position of the seventh part of the bit sequence in the circular buffer is taken as the predefined starting position.

(43) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, the ending bit position of the sixth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(44) In some embodiments, the predefined starting position may be selected in the following manner:

(45) When the code rate of the Polar encoding is greater than the predefined threshold, the starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(46) In some embodiments, the circular buffer includes a first part and a second part. The first part is composed of  $t_1$  continuous bits in the initial bit sequence in a sequential manner or in a bit reversal order (BRO) interleaving manner and the second part is composed of the remaining  $t_2$  bits in the initial bit sequence in the BRO interleaving manner, where  $t_1$  and  $t_2$  are both integers greater than or equal to 0,

(47)  $t_1 \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

$t_1 + t_2 = N$ ,  $N$  is a number of bits in the initial bit sequence, and  $N$  is an integer greater than or equal to 0.

(48) Alternatively, the first part is composed of  $t_2$  continuous bits in the initial bit sequence in the BRO interleaving manner and the second part is composed of the remaining  $t_1$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, where  $t_1$  and  $t_2$  are both integers greater than or equal to 0,

(49)  $t_1 \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

$t_1 + t_2 = N$ ,  $N$  is the number of bits in the initial bit sequence, and  $N$  is an integer greater than or equal to 0.

(50) The first part and the second part are sequentially arranged to form the bit sequence in the circular buffer.

(51) In some embodiments, the initial bit sequence is written as  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$ , the first part is composed of  $t_1$  continuous bits  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.t_{\text{sub}.1}-1}\}$  in the initial bit sequence in the sequential manner or in the BRO interleaving manner, and the second part is composed of the remaining  $N - t_{\text{sub}.1}$  continuous bits  $\{S_{\text{sub}.t_{\text{sub}.1}}, S_{\text{sub}.t_{\text{sub}.1}+1}, \dots, S_{\text{sub}.N-1}\}$  in the initial bit sequence in the BRO interleaving manner.

(52) Alternatively, the first part is composed of  $N - t_{\text{sub}.1}$  continuous bits  $\{S_{\text{sub}.N-1}, S_{\text{sub}.N-2}, \dots, S_{\text{sub}.t_{\text{sub}.1}}\}$  in the initial bit sequence in the BRO interleaving manner, and the second part is composed of the remaining  $t_1$  continuous bits  $\{S_{\text{sub}.t_{\text{sub}.1}-1}, S_{\text{sub}.t_{\text{sub}.1}-2}, \dots, S_{\text{sub}.0}\}$  in the initial bit sequence in the sequential manner or in the BRO interleaving manner.

(53) In some embodiments, the circular buffer includes a third part, a fourth part and a fifth part. The third part is composed of  $t_3$  continuous bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner or in a row-column interleaving manner; the fourth part is determined in the following manner: two continuous bit sequences of length  $t_4$  are selected from the initial bit sequence and arranged in the BRO interleaving manner or in the row-column interleaving manner or in an interlace manner; and the fifth part is composed of  $t_5$  bits in the initial bit sequence, where  $t_3$ ,  $t_4$  and  $t_5$  are all integers greater than or equal to 0,  $t_3 + 2 \times t_4 + t_5 = N$ ,

(54)  $t_3 \in [\frac{1}{8}N, \frac{7}{8}N]$  and  $t_4 \in [\frac{1}{16}N, \frac{7}{16}N]$ .

(55) Alternatively, the third part is composed of  $t_5$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner or in the row-column interleaving manner; the fourth part is determined in the following manner: two continuous bit sequences of length  $t_4$  are selected from the initial bit sequence and arranged in the BRO interleaving manner or in the row-column interleaving manner or in the interlace manner; and the fifth part is composed of the remaining  $t_3$  bits in the initial bit sequence, where  $t_3$ ,  $t_4$  and  $t_5$  are all integers greater than or equal to 0,  $t_3 + 2 \times t_4 + t_5 = N$ ,

(56)  $t_3 \in [\frac{1}{8}N, \frac{7}{8}N]$  and  $t_4 \in [\frac{1}{16}N, \frac{7}{16}N]$ .

(57) The third part, the fourth part and the fifth part are sequentially arranged to form the bit sequence in the circular

buffer.

(58) In some embodiments, the initial bit sequence is written as  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$ , the third part is composed of  $t_{\text{sub}.3}$  continuous bits  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.t_{\text{sub}.3}-1}\}$  in the sequential manner or in the BRO interleaving manner or in the row-column interleaving manner; the fourth part is composed of  $t_4$  bits  $\{S_{\text{sub}.N/4}, S_{\text{sub}.N/4+1}, \dots, S_{\text{sub}.N/4+t_{\text{sub}.4}-1}\}$  and  $t_4$  bits  $\{S_{\text{sub}.N/2}, S_{\text{sub}.N/2+1}, \dots, S_{\text{sub}.N/2+t_{\text{sub}.4}-1}\}$  in the BRO interleaving manner or in the row-column interleaving manner or in the interlace manner; and the fifth part is composed of the remaining  $N-t_{\text{sub}.3}-2 \times t_4$  bits  $\{S_{\text{sub}.t_{\text{sub}.3}}, S_{\text{sub}.t_{\text{sub}.3}+1}, \dots, S_{\text{sub}.N/4-1}\}$ ,  $\{S_{\text{sub}.N/4+t_{\text{sub}.4}}, S_{\text{sub}.N/4+t_{\text{sub}.4}+1}, \dots, S_{\text{sub}.N/2-1}\}$  and  $\{S_{\text{sub}.N/2+t_{\text{sub}.4}}, S_{\text{sub}.N/2+t_{\text{sub}.4}+1}, \dots, S_{\text{sub}.N-1}\}$  in the initial bit sequence in the sequential manner or in the BRO interleaving manner or in the row-column interleaving manner, where  $\{S_{\text{sub}.t_{\text{sub}.3}}, S_{\text{sub}.t_{\text{sub}.3}+1}, \dots, S_{\text{sub}.N/4-1}\} = \emptyset$  for  $t_{\text{sub}.3} = N/4$  and  $\{S_{\text{sub}.N/4+t_{\text{sub}.4}}, S_{\text{sub}.N/4+t_{\text{sub}.4}+1}, \dots, S_{\text{sub}.N/2-1}\} = \emptyset$  for  $t_{\text{sub}.4} = N/4$ , where  $\emptyset$  represents an empty set.

(59) Alternatively, the third part is composed of  $N-t_{\text{sub}.3}-2 \times t_{\text{sub}.4}$  bits  $\{S_{\text{sub}.N-1}, S_{\text{sub}.N-2}, \dots, S_{\text{sub}.N/2+t_{\text{sub}.4}}\}$ ,  $\{S_{\text{sub}.N/2-1}, S_{\text{sub}.N/2-2}, \dots, S_{\text{sub}.N/4+t_{\text{sub}.4}}\}$  and  $\{S_{\text{sub}.N/4-1}, S_{\text{sub}.N/4-2}, \dots, S_{\text{sub}.t_{\text{sub}.3}}\}$  in the sequential manner or in the BRO interleaving manner or in the row-column interleaving manner; the fourth part is composed of  $t_4$  bits  $\{S_{\text{sub}.N/4+t_{\text{sub}.4}}, S_{\text{sub}.N/4+t_{\text{sub}.4}-2}, \dots, S_{\text{sub}.N/4}\}$  and  $t_4$  bits  $\{S_{\text{sub}.N/2+t_{\text{sub}.4}-1}, S_{\text{sub}.N/2+t_{\text{sub}.4}-2}, \dots, S_{\text{sub}.N/2}\}$  in the BRO interleaving manner or in the row-column interleaving manner or in the interlace manner; and the fifth part is composed of a bit sequence  $\{S_{\text{sub}.t_{\text{sub}.3}-1}, S_{\text{sub}.t_{\text{sub}.3}-2}, \dots, S_{\text{sub}.0}\}$  in the sequential manner or in the BRO interleaving manner or in the row-column interleaving manner, where  $\{S_{\text{sub}.t_{\text{sub}.3}}, S_{\text{sub}.t_{\text{sub}.3}+1}, \dots, S_{\text{sub}.N/4-1}\} = \emptyset$  for  $t_{\text{sub}.3} = N/4$  and  $\{S_{\text{sub}.N/4+t_{\text{sub}.4}}, S_{\text{sub}.N/4+t_{\text{sub}.4}+1}, \dots, S_{\text{sub}.N/2-1}\} = \emptyset$  for  $t_{\text{sub}.4} = N/4$ .

(60) In some embodiments, the predefined starting position is selected in one of the following manners:

(61) The starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(62) The position of  $P_{\text{sub}.0} = M-1$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer and  $M$  is the length of the bit sequence to be transmitted.

(63) The position of  $P_{\text{sub}.0} = N-M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is the length of the initial bit sequence.

(64) The ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position. In some embodiments, the circular buffer includes the sixth part, the seventh part, the eighth part and the ninth part. The sixth part is composed of  $t_{\text{sub}.6}$  bits in the initial bit sequence in the BRO interleaving manner, the seventh part is composed of  $t_{\text{sub}.7}$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, the eighth part is composed of  $t_{\text{sub}.8}$  bits in the initial bit sequence in the BRO interleaving manner, and the ninth part is composed of  $t_{\text{sub}.9}$  bits in the initial bit sequence in the BRO interleaving manner, where  $t_{\text{sub}.6}$ ,  $t_{\text{sub}.7}$ ,  $t_{\text{sub}.8}$  and  $t_{\text{sub}.9}$  are all integers greater than or equal to 0,

(65)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,  $(t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,  
and  $t_{\text{sub}.6} + t_{\text{sub}.7} + t_{\text{sub}.8} + t_{\text{sub}.9} = N$ .

(66) Alternatively, the sixth part is composed of  $t_{\text{sub}.9}$  bits in the initial bit sequence in the BRO interleaving manner, the seventh part is composed of  $t_{\text{sub}.8}$  bits in the initial bit sequence in the BRO interleaving manner, the eighth part is composed of  $t_{\text{sub}.7}$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, and the ninth part is composed of  $t_{\text{sub}.6}$  bits in the initial bit sequence in the BRO interleaving manner, where  $t_{\text{sub}.6}$ ,  $t_{\text{sub}.7}$ ,  $t_{\text{sub}.8}$  and  $t_{\text{sub}.9}$  are all integers greater than or equal to 0,

(67)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,  $(t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,  
and  $t_{\text{sub}.6} + t_{\text{sub}.7} + t_{\text{sub}.8} + t_{\text{sub}.9} = N$ .

(68) In some embodiments, the initial bit sequence is written as  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$ ; the sixth part is composed of  $t_{\text{sub}.6}$  bits  $\{I_{\text{sub}.1}\}$  in the BRO interleaving manner, where  $\{I_{\text{sub}.1}\}$  includes an intersection of a bit sequence set  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.a-1}\}$  and a bit sequence set  $\{S_{\text{sub}.BRO(j)}\}$ , where  $a$  is an integer greater than or equal to 0 and less than or equal to  $N$ ,  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.a-1}\} = \emptyset$  for  $a=0$ ,  $j=M, \dots, N-1$ , and  $M$  is the length of the bit sequence to be transmitted; the seventh part is composed of  $t_{\text{sub}.7}$  bits  $\{I_{\text{sub}.2}\}$  in the sequential manner or in the BRO interleaving manner, where  $\{I_{\text{sub}.2}\}$  is a difference set of the bit sequence set  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.a-1}\}$  and a bit sequence set  $\{I_{\text{sub}.1}\}$ ; the ninth part is composed of  $t_{\text{sub}.9}$  bits  $\{I_{\text{sub}.4}\}$  in the BRO interleaving manner, where  $\{I_{\text{sub}.4}\}$  includes an intersection of a bit sequence set  $\{S_{\text{sub}.a}, S_{\text{sub}.a+1}, \dots, S_{\text{sub}.N-1}\}$  and the bit sequence set  $\{S_{\text{sub}.BRO(j)}\}$ , and  $\{S_{\text{sub}.a}, S_{\text{sub}.a+1}, \dots, S_{\text{sub}.N-1}\} = \emptyset$  for  $a=N$ ; and the eighth part is composed of  $t_{\text{sub}.8}$  bits  $\{I_{\text{sub}.3}\}$  in the BRO interleaving manner, where  $\{I_{\text{sub}.3}\}$  is a difference set of the bit sequence set  $\{S_{\text{sub}.a}, S_{\text{sub}.a+1}, \dots, S_{\text{sub}.N-1}\}$  and a bit sequence set  $\{I_{\text{sub}.4}\}$ .

(69) Alternatively, the initial bit sequence is written as  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$ ; the sixth part is composed of  $t_{\text{sub}.9}$  bits  $\{I_{\text{sub}.4}\}$  in the BRO interleaving manner, where  $\{I_{\text{sub}.4}\}$  includes an intersection of a bit sequence set  $\{S_{\text{sub}.N-1}, S_{\text{sub}.N-2}, \dots, S_{\text{sub}.a}\}$  and the bit sequence set  $\{S_{\text{sub}.BRO(j)}\}$ , where  $a$  is an integer greater than or equal to 0 and less than or equal to  $N$ ,  $j=N-1, N-2, \dots, M$ ,  $M$  is the length of the bit sequence to be transmitted and  $\{S_{\text{sub}.N-1}, S_{\text{sub}.N-2}, \dots, S_{\text{sub}.a}\} = \emptyset$  for  $a=N$ ; the seventh part is composed of  $t_{\text{sub}.8}$  bits  $\{I_{\text{sub}.3}\}$  in the BRO interleaving manner, where  $\{I_{\text{sub}.3}\}$  is a difference set of the bit sequence set  $\{S_{\text{sub}.N-1}, S_{\text{sub}.N-2}, \dots, S_{\text{sub}.a}\}$  and

the bit sequence set  $\{I_{\text{sub.4}}\}$ , the ninth part is composed of  $t_{\text{sub.6}}$  bits  $\{I_{\text{sub.1}}\}$  in the sequential manner or in the BRO interleaving manner, where  $\{I_{\text{sub.1}}\}$  includes an intersection of a bit sequence set  $\{S_{\text{sub.a-1}}, S_{\text{sub.a-2}}, \dots, S_{\text{sub.0}}\}$  and the bit sequence set  $\{S_{\text{sub.BRO(j)}}\}$ , and  $\{S_{\text{sub.0}}, S_{\text{sub.1}}, \dots, S_{\text{sub.a-1}}\} = \emptyset$  for  $a=0$ ; and the eighth part is composed of  $t_{\text{sub.7}}$  bits  $\{I_{\text{sub.2}}\}$  in the sequential manner or in the BRO interleaving manner, where  $\{I_{\text{sub.2}}\}$  is a difference set of the bit sequence set  $\{S_{\text{sub.a-1}}, S_{\text{sub.a-2}}, \dots, S_{\text{sub.0}}\}$  and the bit sequence set  $\{I_{\text{sub.1}}\}$ .

(70) The sixth part, the seventh part, the eighth part and the ninth part are sequentially arranged to form the bit sequence in the circular buffer.

(71) In some embodiments, the predefined starting position is selected according to the code rate of the Polar encoding.

(72) In some embodiments, the predefined starting position is selected in one of the following manners:

(73) When the code rate of the Polar encoding is less than or equal to the predefined threshold, the position of  $P_{\text{sub.0}}=N-M$  is taken as the predefined starting position; when the code rate of the Polar encoding is greater than the predefined threshold, the starting bit position of the seventh part of the bit sequence in the circular buffer is taken as the predefined starting position.

(74) When the code rate of the Polar encoding is less than or equal to the predefined threshold, the ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position; when the code rate of the Polar encoding is greater than the predefined threshold, the ending bit position of the eighth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(75) When the code rate of the Polar encoding is less than or equal to the predefined threshold, the starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position; when the code rate of Polar encoding code is greater than the predefined threshold, the starting bit position of the seventh part of the bit sequence in the circular buffer is taken as the predefined starting position.

(76) When the code rate of the Polar encoding is less than or equal to the predefined threshold, the position of  $P_{\text{sub.0}}=M-1$  is taken as the predefined starting position; when the code rate of the Polar encoding is greater than the predefined threshold, the ending bit position of the eighth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(77) It is to be noted that the predefined starting position needs to be selected according to the code rate of the Polar encoding which may be seen from the above manners in which the predefined starting option is selected.

(78) In some embodiments, the circular buffer includes the sixth part, the seventh part, the eighth part and the ninth part. The sixth part is composed of  $t_{\text{sub.6}}$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, the seventh part is composed of  $t_{\text{sub.7}}$  bits in the initial bit sequence in the BRO interleaving manner, the eighth part is composed of  $t_{\text{sub.8}}$  bits in the initial bit sequence in the BRO interleaving manner, and the ninth part is composed of  $t_{\text{sub.9}}$  bits in the initial bit sequence in the BRO interleaving manner, where  $t_{\text{sub.6}}, t_{\text{sub.7}}, t_{\text{sub.8}}$  and  $t_{\text{sub.9}}$  are all integers greater than or equal to 0,

(79)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N], (t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,  
and  $t_{\text{sub.6}}+t_{\text{sub.7}}+t_{\text{sub.8}}+t_{\text{sub.9}}=N$ .

(80) Alternatively, the sixth part is composed of  $t_{\text{sub.9}}$  bits in the initial bit sequence in the BRO interleaving manner, the seventh part is composed of  $t_{\text{sub.8}}$  bits in the initial bit sequence in the BRO interleaving manner, the eighth part is composed of  $t_{\text{sub.7}}$  bits in the initial bit sequence in the BRO interleaving manner, and the ninth part is composed of  $t_{\text{sub.6}}$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, where  $t_{\text{sub.6}}, t_{\text{sub.7}}, t_{\text{sub.8}}$  and  $t_{\text{sub.9}}$  are all integers greater than or equal to 0,

(81)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N], (t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,  
and  $t_{\text{sub.6}}+t_{\text{sub.7}}+t_{\text{sub.8}}+t_{\text{sub.9}}=N$ .

(82) In some embodiments, the initial bit sequence is written as  $\{S_{\text{sub.0}}, S_{\text{sub.1}}, \dots, S_{\text{sub.N-1}}\}$ ; the seventh part is composed of  $t_{\text{sub.7}}$  bits  $\{I_{\text{sub.2}}\}$  in the BRO interleaving manner, where  $\{I_{\text{sub.2}}\}$  includes an intersection of the bit sequence set  $\{S_{\text{sub.0}}, S_{\text{sub.1}}, \dots, S_{\text{sub.a-1}}\}$  and the bit sequence set  $\{S_{\text{sub.BRO(j)}}\}$ , where  $a$  is an integer greater than or equal to 0 and less than or equal to  $N$ ,  $\{S_{\text{sub.0}}, S_{\text{sub.1}}, \dots, S_{\text{sub.a-1}}\} = \emptyset$  for  $a=0, j=M, \dots, N-1$ , and  $M$  is the length of the bit sequence to be transmitted; the sixth part is composed of  $t_{\text{sub.6}}$  bits  $\{I_{\text{sub.1}}\}$  in the sequential manner or in the BRO interleaving manner, where  $\{I_{\text{sub.1}}\}$  is a difference set of the bit sequence set  $\{S_{\text{sub.0}}, S_{\text{sub.1}}, \dots, S_{\text{sub.a-1}}\}$  and a bit sequence set  $\{I_{\text{sub.2}}\}$ ; the eighth part is composed of  $t_{\text{sub.8}}$  bits  $\{I_{\text{sub.3}}\}$  in the BRO interleaving manner, where  $\{I_{\text{sub.3}}\}$  includes an intersection of the bit sequence set  $\{S_{\text{sub.a}}, S_{\text{sub.a+1}}, \dots, S_{\text{sub.N-1}}\}$  and the bit sequence set  $\{S_{\text{sub.BRO(j)}}\}$ , and  $\{S_{\text{sub.a}}, S_{\text{sub.a+1}}, \dots, S_{\text{sub.N-1}}\} = \emptyset$  for  $a=N$ ; and the ninth part is composed of  $t_{\text{sub.9}}$  bits  $\{I_{\text{sub.4}}\}$  in the BRO interleaving manner, where  $\{I_{\text{sub.4}}\}$  is a difference set of the bit sequence set  $\{S_{\text{sub.a}}, S_{\text{sub.a+1}}, \dots, S_{\text{sub.N-1}}\}$  and a bit sequence set  $\{I_{\text{sub.3}}\}$ .

(83) Alternatively, the initial bit sequence is written as  $\{S_{\text{sub.0}}, S_{\text{sub.1}}, \dots, S_{\text{sub.N-1}}\}$ ; the seventh part is composed of  $t_{\text{sub.8}}$  bits  $\{I_{\text{sub.3}}\}$  in the BRO interleaving manner, where  $\{I_{\text{sub.3}}\}$  includes an intersection of the bit sequence set  $\{S_{\text{sub.N-1}}, S_{\text{sub.N-2}}, \dots, S_{\text{sub.a}}\}$  and the bit sequence set  $\{S_{\text{sub.BRO(j)}}\}$ , where  $a$  is an integer greater than or equal to 0 and less than or equal to  $N$ ,  $j \in \{M, \dots, N-1\}$ ,  $M$  is the length of the bit sequence to be transmitted and  $\{S_{\text{sub.N-1}}, S_{\text{sub.N-2}}, \dots, S_{\text{sub.a}}\} = \emptyset$  for  $a=N$ ; the sixth part is composed of  $t_{\text{sub.9}}$  bits  $\{I_{\text{sub.4}}\}$  in the BRO interleaving manner, where  $\{I_{\text{sub.4}}\}$  is a difference set of the bit sequence set  $\{S_{\text{sub.N-1}}, S_{\text{sub.N-2}}, \dots, S_{\text{sub.a}}\}$  and the bit sequence set  $\{I_{\text{sub.3}}\}$ ; the eighth part is composed of  $t_{\text{sub.7}}$  bits  $\{I_{\text{sub.2}}\}$  in the BRO interleaving manner, where  $\{I_{\text{sub.2}}\}$  includes an intersection of the bit sequence set  $\{S_{\text{sub.a-1}}, S_{\text{sub.a-2}}, \dots, S_{\text{sub.0}}\}$  and the bit

sequence set  $\{S_{\text{sub.BRO}(j)}\}$ , and  $\{S_{\text{sub.a-1}}, S_{\text{sub.a-2}}, \dots, S_{\text{sub.0}}\} = \emptyset$  for  $a=0$ ; and the ninth part is composed of  $t_{\text{sub.6 bits}} \{I_{\text{sub.1}}\}$  in the sequential manner or in the sequential manner or in the BRO interleaving manner, where  $\{S_{\text{sub.i.sub.1}}\}$  is a difference set of the bit sequence set  $\{S_{\text{sub.a-1}}, S_{\text{sub.a-2}}, \dots, S_{\text{sub.0}}\}$  and the bit sequence set  $\{I_{\text{sub.2}}\}$ .

(84) The sixth part, the seventh part, the eighth part and the ninth part are sequentially arranged to form the bit sequence in the circular buffer.

(85) In some embodiments, the predefined starting position is selected in one of the following manners:

(86) When the code rate of the Polar encoding is less than or equal to the predefined threshold, the starting bit position of the eighth part of the bit sequence in the circular buffer is taken as the predefined starting position; when the code rate of the Polar encoding is greater than the predefined threshold, the starting bit position of the ninth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(87) When the code rate of the Polar encoding is less than or equal to the predefined threshold, if  $M \leq t_{\text{sub.8}} + t_{\text{sub.9}}$ , the position of  $P_{\text{sub.0}} = t_{\text{sub.6}} + t_{\text{sub.7}} + M - 1$  is taken as the predefined starting position, and if  $M > t_{\text{sub.8}} + t_{\text{sub.9}}$ , the position of  $P_{\text{sub.0}} = M - 1 - t_{\text{sub.8}} - t_{\text{sub.9}}$  is taken as the predefined starting position; when the code rate of the Polar encoding is greater than the predefined threshold, the ending bit position of the sixth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(88) When the code rate of the Polar encoding is less than or equal to the predefined threshold, if  $M \leq t_{\text{sub.8}} + t_{\text{sub.9}}$ , the position of  $P_{\text{sub.0}} = t_{\text{sub.8}} + t_{\text{sub.9}} - M$  is taken as the predefined starting position, and if  $M > t_{\text{sub.8}} + t_{\text{sub.9}}$ , the position of  $P_{\text{sub.0}} = N + t_{\text{sub.8}} + t_{\text{sub.9}} - M$  is taken as the predefined starting position; when the code rate of the Polar encoding is greater than the predefined threshold, the starting bit position of the ninth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(89) When the code rate of the Polar encoding is less than or equal to the predefined threshold, the ending bit position of the seventh part of the bit sequence in the circular buffer is taken as the predefined starting position; when the code rate of the Polar encoding is greater than the predefined threshold, the ending bit position of the sixth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(90) It is to be noted that the predefined starting position needs to be selected according to the code rate of the Polar encoding which may be seen from the above manners in which the predefined starting option is selected.

(91) In some embodiments, the predefined threshold is taken from a set  $\{\frac{1}{3}, \frac{1}{2}\}$ , that is, the predefined threshold may be  $\frac{1}{3}$  or  $\frac{1}{2}$ .

(92) In some embodiments, the mother code of the Polar code has a length of  $N = 2^{\lceil \log_2(K/R) \rceil + m}$ , where  $\lceil \cdot \rceil$  represents a ceiling operation,  $R$  is a code rate, and  $m$  is a positive integer.

(93) In some embodiments, the bit sequence in the circular buffer is obtained by performing BRO interleaving on the initial bit sequence  $\{S_{\text{sub.0}}, S_{\text{sub.1}}, \dots, S_{\text{sub.N-1}}\}$ , and a bit  $S_n$  with a bit position index  $n$  in the initial bit sequence is mapped onto a position with a position index  $\text{mod}(\text{BRO}(n) + m, N)$  in the circular buffer by means of a BRO interleaver, where  $n = 0, 1, \dots, N-1$ ,  $m = 0, 1, \dots, N-1$ ,  $m$  is an offset and  $\text{mod}(x_1, x_2)$  represents a remainder of a division  $x_1/x_2$ .

(94) In some embodiments, the bit sequence in the circular buffer is obtained by performing the BRO interleaving on the initial bit sequence  $\{S_{\text{sub.0}}, S_{\text{sub.1}}, \dots, S_{\text{sub.N-1}}\}$ , and the bit  $S_n$  with the bit position index  $n$  in the initial bit sequence is mapped onto a position with a position index  $N - 1 - \text{mod}(\text{BRO}(n) + m, N)$  in the circular buffer by means of the BRO interleaver, where  $n = 0, 1, \dots, N-1$ ,  $m = 0, 1, \dots, N-1$ ,  $m$  is the offset and  $\text{mod}(x_1, x_2)$  represents the remainder of the division  $x_1/x_2$ .

(95) In some embodiments, the predefined starting position is selected in one of the following manners:

(96) The starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(97) The position of  $P_{\text{sub.0}} = M - 1$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub.0}}$  represents the position index of the bit sequence in the circular buffer and  $M$  is the length of the bit sequence to be transmitted.

(98) The position of  $P_{\text{sub.0}} = N - M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub.0}}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is the length of the initial bit sequence.

(99) The ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(100) In some embodiments, sequentially selecting the bit sequence of the specified length from the predefined starting position in the bit sequence in the circular buffer and taking the bit sequence of the specified length as the bit sequence to be transmitted includes the following step:

(101) Bits are sequentially selected in an ascending or descending order of indexes from a predefined position in the bit sequence in the circular buffer, when reaching to an end of the bit sequence in the circular buffer, the selecting is continued from an other end of the bit sequence in the circular buffer until the bit sequence of the specified length is selected, and the bit sequence of the specified length is taken as the bit sequence to be transmitted.

(102) For example, when the bits are read in an ascending order of indexes from the predefined starting position to the ending bit position of the bit sequence in the circular buffer, if the bit sequence of the specified length is not read, the reading is continued from the starting bit position of the bit sequence in the circular buffer until the bit sequence of the specified length is read and the bit sequence of the specified length is taken as the bit sequence to be transmitted. When

the bits are read in the descending order of indexes from the predefined starting position to the starting bit position of the bit sequence in the circular buffer, if the bit sequence of the specified length is not read, the reading is continued from the ending bit position of the bit sequence in the circular buffer until the bit sequence of the specified length is read and the bit sequence of the specified length is taken as the bit sequence to be transmitted.

(103) In some embodiments, when the code rate of the Polar encoding is less than or equal to the predefined threshold, the position of  $P_{\text{sub}.0} = N - M$  in the circular buffer is taken as the predefined starting position and  $M$  bits are sequentially selected in the ascending order of indexes; when the reading goes to an end of the bit sequence in the circular buffer, the reading is continued from the other end of the bit sequence in the circular buffer, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is the length of the initial bit sequence.

(104) In some embodiments, when the code rate of the Polar encoding is greater than the predefined threshold, the starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position and the  $M$  bits are sequentially selected in the ascending order of indexes; when the reading goes to an end of the bit sequence in the circular buffer, the reading is continued from the other end of the bit sequence in the circular buffer, where  $N$  is the length of the initial bit sequence.

(105) A process for determining the predefined starting position may be applied to any one of the above cases where the circular buffer is divided into two parts, three parts and four parts, and may also be applied to any one of the first combination, the second combination, the third combination and the fourth combination, which are not limited in this embodiment.

(106) In some embodiments, the bit sequence to be transmitted is arranged in a same order or in a reverse order of the bit sequence of the specified length read from the circular buffer.

(107) The method in embodiments described above may be implemented by software plus a necessary general-purpose hardware platform, or may of course be implemented by hardware, but in many cases, the former is a preferred implementation mode. The content provided by this embodiment substantially, or the part contributing to the existing art, may be embodied in the form of a software product. The software product is stored on a storage medium (such as a ROM/RAM, a magnetic disk or an optical disk) and includes several instructions for enabling a terminal device (which may be a mobile phone, a computer, a server or a network device) to execute the method according to the embodiments described above.

## Embodiment 2

(108) This embodiment provides a rate matching device for a Polar code. The device may implement the method according to the embodiments described above. What has been described will not be repeated. As used below, the term “module” may be software, hardware or a combination thereof capable of implementing predetermined functions. The device in the embodiment described below is preferably implemented by software, but implementation by hardware or by a combination of software and hardware is also possible and conceived.

(109) FIG. 4 is a block diagram of a device for processing a bit sequence according to this embodiment. As shown in FIG. 4, the device may include a generation module 40, a writing module 42, a reading module 44 and a determination module 46.

(110) The generation module 40 is configured to concatenate  $K$  information bits and  $(N - K)$  frozen bits to generate a bit sequence of  $N$  bits and encode the bit sequence of  $N$  bits by means of a Polar code encoder with a generator matrix of size  $N \times N$  to generate an initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  of  $N$  bits, where  $K$  and  $N$  are both positive integers and  $K$  is less than or equal to  $N$ .

(111) The writing module 42 is configured to divide a circular buffer into  $q$  parts, select bits from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in a non-repeated manner, and write the bits into the  $q$  parts of the circular buffer according to a predefined rule, where  $q = 1, 2, 3$  or  $4$ .

(112) The reading module 44 is configured to sequentially selected a bit sequence of a specified length from a predefined starting position in a bit sequence in the circular buffer.

(113) The determination module 46 is configured to take the bit sequence of the specified length as a bit sequence to be transmitted.

(114) In the above device, the generation module 40 may concatenate  $K$  bit channels as information bits with the  $(N - K)$  frozen bits to generate the bit sequence of  $N$  bits and encode the bit sequence of  $N$  bits by means of the Polar code encoder with the generator matrix of size  $N \times N$  to generate the initial bit sequence of  $N$  bits; the writing module 42 divides the circular buffer into the  $q$  parts, select the bits from the initial bit sequence in the non-repeated manner, and write the bits into the  $q$  parts of the circular buffer according to the predefined rule; the reading module 44 sequentially selects the bit sequence of the specified length from the predefined starting position in the bit sequence in the circular buffer; and the determination module 46 takes the bit sequence of the specified length as the bit sequence to be transmitted. In this way, proper processing and reading rules are used to adapt to the transmission of data bits in different application scenarios, thereby solving the problem in the related art that Polar code hardware has high complexity and has a complicated encoding process in a hybrid automatic repeat request mechanism, significantly reducing the complexity of Polar code hardware and simplifying the encoding process.

(115) In some embodiments, the predefined rule for the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  is determined by a one-to-one mapping interleaving function  $f(n)$  generated according to a data characteristic of the Polar

code, where  $n=0, 1, \dots, N-1$ ,  $f(n)=0, 1, \dots, N-1$ ,  $n$  is a bit position index in the initial bit sequence, and  $f(n)$  is a position index in the circular buffer. The writing module is configured to map a bit  $S_n$  with a bit position index  $n$  in the initial bit sequence onto a position with a position index  $f(n)$  in the circular buffer according to the one-to-one mapping interleaving function  $f(n)$ .

(116) It is to be noted that since a mapping  $\{n\} \rightarrow \{f(n)\}$  is a one-to-one mapping, an inverse function  $p(n)$  of  $f(n)$ , which satisfies a mapping  $\{p(n)\} \rightarrow \{n\}$ , exists. That is, the predefined rule may be determined by a one-to-one mapping interleaving function  $p(n)$  generated according to the data characteristic of the Polar code, where  $n=0, 1, \dots, N-1$ ,  $p(n)=0, 1, \dots, N-1$ ,  $p(n)$  is a bit position index in the initial bit sequence, and  $n$  is a position index in the circular buffer. The step of selecting the bits from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in the non-repeated manner and writing the bits into the  $q$  parts of the circular buffer according to the predefined rule includes: mapping a bit  $S_{\text{sub}.p(n)}$  with a bit position index  $p(n)$  in the initial bit sequence onto a position with a position index  $n$  in the circular buffer according to the one-to-one mapping interleaving function  $p(n)$ .

(117) In some embodiments, the one-to-one mapping interleaving function  $f(n)$  has the following nesting characteristic: a mapping  $\{n_{\text{sub}.0}\} \rightarrow \{f(n_{\text{sub}.0})\}$  may be directly obtained by deleting an element greater than  $N_{\text{sub}.0}$  from a sequence  $\{n\}$  and a sequence  $\{f(n)\}$  in the mapping  $\{n\} \rightarrow \{f(n)\}$  of the one-to-one mapping interleaving function, where  $n_{\text{sub}.0}=0, 1, 2, \dots, N_{\text{sub}.0}-1$  and  $N_{\text{sub}.0}$  is a positive integer less than or equal to  $N$ .

(118) In some embodiments, the predefined rule for the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  may be performed by mapping the bit  $S_{\text{sub}.n}$  with the bit position index  $n$  in the initial bit sequence onto a position with a position index  $\text{mod}(f(n)+m, N)$  in the circular buffer according to the data characteristic of the Polar code, where  $m=0, 1, \dots, N-1$ ,  $m$  is an offset and  $\text{mod}(x_{\text{sub}.1}, x_{\text{sub}.2})$  represents a remainder of a division  $x_{\text{sub}.1}/x_{\text{sub}.2}$ , where  $x_{\text{sub}.1}$  is an integer and  $x_{\text{sub}.2}$  is a positive integer.

(119) In some embodiments, the predefined starting position is selected in one of the following manners:

(120) A starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(121) A position of  $P_{\text{sub}.0}=M-1$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents a position index of the bit sequence in the circular buffer and  $M$  is a length of the bit sequence to be transmitted.

(122) A position of  $P_{\text{sub}.0}=N-M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is a length of the initial bit sequence.

(123) An ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(124) In some embodiments, the predefined starting position is selected according to a code rate of the Polar encoding.

(125) In some embodiments, the predefined starting position may be selected in the following manner:

(126) When the code rate of the Polar encoding is less than or equal to a predefined threshold, the position of  $P_{\text{sub}.0}=N-M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is the length of the initial bit sequence.

(127) It is to be noted that since the predefined starting position is selected according to the code rate of the Polar encoding, when the code rate of the Polar encoding is greater than the predefined threshold, the predefined starting position is selected in one of the following manners:

(128) The starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(129) The position of  $P_{\text{sub}.0}=M-1$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer and  $M$  is the length of the bit sequence to be transmitted.

(130) The ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(131) When the circular buffer is composed of a sixth part, a seventh part, an eighth part and a ninth part arranged sequentially, a starting bit position of the seventh part of the bit sequence in the circular buffer is taken as the predefined starting position.

(132) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, an ending bit position of the eighth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(133) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, a starting bit position of the eighth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(134) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, a starting bit position of the ninth part of the bit sequence in the circular buffer is taken as the predefined starting position.

(135) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, if  $M \leq t_{\text{sub}.8} + t_{\text{sub}.9}$ , a position of  $P_{\text{sub}.0} = t_{\text{sub}.6} + t_{\text{sub}.7} + M - 1$  is taken as the predefined starting position; if  $M > t_{\text{sub}.8} + t_{\text{sub}.9}$ , a position of  $P_{\text{sub}.0} = M - 1 - t_{\text{sub}.8} - t_{\text{sub}.9}$  is taken as the predefined starting position, where  $M$  is the length of the bit sequence to be transmitted,  $t_{\text{sub}.6}$  is a length in bits of the sixth part,  $t_{\text{sub}.7}$  is a length in bits of the seventh part,  $t_{\text{sub}.8}$  is a length in bits of the eighth part, and  $t_{\text{sub}.9}$  is a length in bits of the ninth part.

- (136) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, an ending bit position of the sixth part of the bit sequence in the circular buffer is taken as the predefined starting position.
- (137) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, if  $M \leq t_{\text{sub}.8} + t_{\text{sub}.9}$ , a position of  $P_{\text{sub}.0} = t_{\text{sub}.8} + t_{\text{sub}.9} - M$  is taken as the predefined starting position; if  $M > t_{\text{sub}.8} + t_{\text{sub}.9}$ , a position of  $P_{\text{sub}.0} = N + t_{\text{sub}.8} + t_{\text{sub}.9} - M$  is taken as the predefined starting position, where  $M$  is the length of the bit sequence to be transmitted,  $t_{\text{sub}.6}$  is the length in bits of the sixth part,  $t_{\text{sub}.7}$  is the length in bits of the seventh part,  $t_{\text{sub}.8}$  is the length in bits of the eighth part, and  $t_{\text{sub}.9}$  is the length in bits of the ninth part.
- (138) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, the starting bit position of the ninth part of the bit sequence in the circular buffer is taken as the predefined starting position.
- (139) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, an ending bit position of the seventh part of the bit sequence in the circular buffer is taken as the predefined starting position.
- (140) When the circular buffer is composed of the sixth part, the seventh part, the eighth part and the ninth part arranged sequentially, the ending bit position of the sixth part of the bit sequence in the circular buffer is taken as the predefined starting position.
- (141) In some embodiments, the predefined starting position may be selected in the following manner:
- (142) When the code rate of the Polar encoding is greater than the predefined threshold, the starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.
- (143) In some embodiments, the circular buffer includes a first part and a second part. The first part is composed of  $t_1$  continuous bits in the initial bit sequence in a sequential manner or in a BRO interleaving manner and the second part is composed of the remaining  $t_2$  bits in the initial bit sequence in the BRO interleaving manner, where  $t_1$  and  $t_2$  are both integers greater than or equal to 0,
- (144)  $t_1 \in [\frac{1}{8}N, \frac{7}{8}N]$ ,  
 $t_1 + t_2 = N$ ,  $N$  is a number of bits in the initial bit sequence, and  $N$  is an integer greater than or equal to 0.
- (145) Alternatively, the first part is composed of  $t_2$  continuous bits in the initial bit sequence in the BRO interleaving manner and the second part is composed of the remaining  $t_1$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, where  $t_1$  and  $t_2$  are both integers greater than or equal to 0,
- (146)  $0 \leq t_1 \in [\frac{1}{8}N, \frac{7}{8}N]$ ,  
 $t_1 + t_2 = N$ ,  $N$  is the number of bits in the initial bit sequence, and  $N$  is an integer greater than or equal to 0.
- (147) The first part and the second part are sequentially arranged to form the bit sequence in the circular buffer.
- (148) In some embodiments, the circular buffer includes a third part, a fourth part and a fifth part. The third part is composed of  $t_3$  continuous bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner or in a row-column interleaving manner; the fourth part is determined in the following manner: two continuous bit sequences of length  $t_4$  are selected from the initial bit sequence and arranged in the BRO interleaving manner or in the row-column interleaving manner or in an interlace manner; and the fifth part is composed of the remaining  $t_5$  bits in the initial bit sequence, where  $t_3$ ,  $t_4$  and  $t_5$  are all integers greater than or equal to 0,  $t_3 + 2 \times t_4 + t_5 = N$ ,
- (149)  $t_3 \in [\frac{1}{8}N, \frac{7}{8}N]$  and  $t_4 \in [\frac{1}{16}N, \frac{7}{16}N]$ .
- (150) Alternatively, the third part is composed of  $t_5$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner or in the row-column interleaving manner; the fourth part is determined in the following manner: two continuous bit sequences of length  $t_4$  are selected from the initial bit sequence and arranged in the BRO interleaving manner or in the row-column interleaving manner or in the interlace manner; and the fifth part is composed of the remaining  $t_3$  bits in the initial bit sequence, where  $t_3$ ,  $t_4$  and  $t_5$  are all integers greater than or equal to 0,  $t_3 + 2 \times t_4 + t_5 = N$ ,
- (151)  $t_3 \in [\frac{1}{8}N, \frac{7}{8}N]$  and  $t_4 \in [\frac{1}{16}N, \frac{7}{16}N]$ .
- (152) The third part, the fourth part and the fifth part are sequentially arranged to form the bit sequence in the circular buffer.
- (153) In some embodiments, the predefined starting position is selected in one of the following manners:
- (154) The starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.
- (155) The position of  $P_{\text{sub}.0} = M - 1$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer and  $M$  is the length of the bit sequence to be transmitted.
- (156) The position of  $P_{\text{sub}.0} = N - M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is the length of the initial bit sequence.
- (157) The ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position.
- (158) In some embodiments, the circular buffer includes the sixth part, the seventh part, the eighth part and the ninth part. The sixth part is composed of  $t_{\text{sub}.6}$  bits in the initial bit sequence in the BRO interleaving manner, the seventh part is composed of  $t_{\text{sub}.7}$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, the eighth part is composed of  $t_{\text{sub}.8}$  bits in the initial bit sequence in the BRO interleaving manner, and the ninth part is composed of  $t_{\text{sub}.9}$  bits in the initial bit sequence in the BRO interleaving manner, where  $t_{\text{sub}.6}$ ,  $t_{\text{sub}.7}$ ,  $t_{\text{sub}.8}$  and

t.sub.9 are all integers greater than or equal to 0,

(159)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N], (t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

and t.sub.6+t.sub.7+t.sub.8+t.sub.9=N.

(160) Alternatively, the sixth part is composed of t.sub.9 bits in the initial bit sequence in the BRO interleaving manner, the seventh part is composed of t.sub.8 bits in the initial bit sequence in the BRO interleaving manner, the eighth part is composed of t.sub.7 bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, and the ninth part is composed of t.sub.6 bits in the initial bit sequence in the BRO interleaving manner, where t.sub.6, t.sub.7, t.sub.8 and t.sub.9 are all integers greater than or equal to 0,

(161)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N], (t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

and t.sub.6+t.sub.7+t.sub.8+t.sub.9=N.

(162) In some embodiments, the circular buffer includes the sixth part, the seventh part, the eighth part and the ninth part. The sixth part is composed of t.sub.6 bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, the seventh part is composed of t.sub.7 bits in the initial bit sequence in the BRO interleaving manner, the eighth part is composed of t.sub.8 bits in the initial bit sequence in the BRO interleaving manner, and the ninth part is composed of t.sub.9 bits in the initial bit sequence in the BRO interleaving manner, where t.sub.6, t.sub.7, t.sub.8 and t.sub.9 are all integers greater than or equal to 0,

(163)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N], (t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

and t.sub.6+t.sub.7+t.sub.8+t.sub.9=N.

(164) Alternatively, the sixth part is composed of t.sub.9 bits in the initial bit sequence in the BRO interleaving manner, the seventh part is composed of t.sub.8 bits in the initial bit sequence in the BRO interleaving manner, the eighth part is composed of t.sub.7 bits in the initial bit sequence in the BRO interleaving manner, and the ninth part is composed of t.sub.6 bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, where t.sub.6, t.sub.7, t.sub.8 and t.sub.9 are all integers greater than or equal to 0,

(165)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N], (t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

and t.sub.6+t.sub.7+t.sub.8+t.sub.9=N.

(166) In some embodiments, a mother code of the Polar code has a length of  $N=2^{\lceil \log_2(K/R) \rceil + m}$ , where  $\lceil \cdot \rceil$  represents a ceiling operation and m is a positive integer.

(167) In some embodiments, the bit sequence in the circular buffer is obtained by performing BRO interleaving on the initial bit sequence {S.sub.0, S.sub.1, . . . , S.sub.N-1}, and a bit S<sub>n</sub> with a bit position index n in the initial bit sequence is mapped onto a position with a position index mod(BRO(n)+m, N) in the circular buffer by means of a BRO interleaver, where n=0, 1, . . . , N-1, m=0, 1, . . . , N-1, m is an offset and mod(x1,x2) represents a remainder of a division x1/x2.

(168) In some embodiments, the bit sequence in the circular buffer is obtained by performing the BRO interleaving on the initial bit sequence {S.sub.0, S.sub.1, . . . , S.sub.N-1}, and the bit S<sub>n</sub> with the bit position index n in the initial bit sequence is mapped onto a position with a position index N-1-mod(BRO(n)+m, N) in the circular buffer by means of the BRO interleaver, where n=0, 1, . . . , N-1, m=0, 1, . . . , N-1, m is the offset and mod(x1,x2) represents the remainder of the division x1/x2.

### Embodiment 3

(169) This embodiment provides a rate matching device for a Polar code to illustrate an application body of the device in the embodiments described above. The system may implement the method according to the embodiments described above. What has been described will not be repeated in this embodiment.

(170) FIG. 5 is a block diagram of a device for processing a bit sequence according to this embodiment. As shown in FIG. 5, the device may include a processor 50 and a memory 52.

(171) The memory 52 is configured to store instructions executable by the processor. The processor 50 is configured to perform, according to the instructions stored in the memory, the following operations: K bit channels used as information bits and (N-K) frozen bits are concatenated to generate a bit sequence of N bits, and the bit sequence of N bits is encoded by means of a Polar code encoder with a generator matrix of size N×N to generate an initial bit sequence {S.sub.0, S.sub.1, . . . , S.sub.N-1} of N bits, where K and N are both positive integers and K is less than or equal to N; a circular buffer is divided into q parts, bits are selected from the initial bit sequence {S.sub.0, S.sub.1, . . . , S.sub.N-1} in a non-repeated manner, and the bits are written into each part of the circular buffer according to a predefined rule, where q=1, 2, 3 or 4; and a bit sequence of a specified length is sequentially selected from a predefined starting position in a bit sequence in the circular buffer and the bit sequence of the specified length is taken as a bit sequence to be transmitted.

(172) In the above device, Polar code is performed on a bit sequence to be transmitted, the bit sequence subject to the Polar code is processed according to a predefined rule to obtain the bit sequence in the circular buffer, and the bit sequence of the specified length is sequentially selected from the predefined starting position and taken as the bit sequence to be transmitted. In this way, proper processing and reading rules are used to adapt to the transmission of data bits in different application scenarios, thereby solving the problem in the related art that Polar code hardware has high complexity and has a complicated encoding process in a hybrid automatic repeat request mechanism, significantly reducing the complexity of Polar code hardware and simplifying the encoding process.

(173) In some embodiments, the processor is further configured to perform, according to the instructions stored in the memory, the following operations: the predefined rule for the initial bit sequence {S.sub.0, S.sub.1, . . . , S.sub.N-1} is



generated by a one-to-one mapping interleaving function  $f(n)$  generated according to a data characteristic of the Polar code, where  $n=0, 1, \dots, N-1$ ,  $f(n)=0, 1, \dots, N-1$ ,  $n$  is a bit position index in the initial bit sequence, and  $f(n)$  is a position index in the circular buffer; and a bit  $S_n$  with a bit position index  $n$  in the initial bit sequence is mapped onto a position with a position index  $f(n)$  in the circular buffer according to the one-to-one mapping interleaving function  $f(n)$ . (174) It is to be noted that since a mapping  $\{n\} \rightarrow \{f(n)\}$  is a one-to-one mapping, an inverse function  $p(n)$  of  $f(n)$ , which satisfies a mapping  $\{p(n)\} \rightarrow \{n\}$ , exists. That is, the predefined rule may be determined by a one-to-one mapping interleaving function  $p(n)$  generated according to the data characteristic of the Polar code, where  $n=0, 1, \dots, N-1$ ,  $p(n)=0, 1, \dots, N-1$ ,  $p(n)$  is a bit position index in the initial bit sequence, and  $n$  is a position index in the circular buffer. The operation of selecting the bits from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in the non-repeated manner and writing the bits into the  $q$  parts of the circular buffer according to the predefined rule includes: mapping a bit  $S_{\text{sub}.p(n)}$  with a bit position index  $p(n)$  in the initial bit sequence onto a position with a position index  $n$  in the circular buffer according to the one-to-one mapping interleaving function  $p(n)$ .

(175) In some embodiments, the one-to-one mapping interleaving function  $f(n)$  has the following nesting characteristic: a mapping  $\{n_{\text{sub}.0}\} \rightarrow \{f(n_{\text{sub}.0})\}$  may be directly obtained by deleting an element greater than  $N_{\text{sub}.0}$  from a sequence  $\{n\}$  and a sequence  $\{f(n)\}$  in the mapping  $\{n\} \rightarrow \{f(n)\}$  of the one-to-one mapping interleaving function, where  $n_{\text{sub}.0}=0, 1, 2, \dots, N_{\text{sub}.0}-1$  and  $N_{\text{sub}.0}$  is a positive integer less than or equal to  $N$ .

(176) In some embodiments, the predefined rule for the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  may be performed by mapping the bit  $S_{\text{sub}.n}$  with the bit position index  $n$  in the initial bit sequence onto a position with a position index  $\text{mod}(f(n)+m, N)$  in the circular buffer according to the data characteristic of the Polar code, where  $m=0, 1, \dots, N-1$ ,  $m$  is an offset and  $\text{mod}(x_{\text{sub}.1}, x_{\text{sub}.2})$  represents a remainder of a division  $x_{\text{sub}.1}/x_{\text{sub}.2}$ , where  $x_{\text{sub}.1}$  is an integer and  $x_{\text{sub}.2}$  is a positive integer.

(177) In some embodiments, the predefined starting position is selected in one of the following manners:

(178) A starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(179) A position of  $P_{\text{sub}.0}=M-1$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents a position index of the bit sequence in the circular buffer and  $M$  is a length of the bit sequence to be transmitted.

(180) A position of  $P_{\text{sub}.0}=N-M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is a length of the initial bit sequence.

(181) An ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(182) In some embodiments, the predefined starting position is selected according to a code rate of the Polar encoding.

(183) In some embodiments, the predefined starting position may be selected in the following manner:

(184) When the code rate of the Polar encoding is less than or equal to a predefined threshold, the position of  $P_{\text{sub}.0}=N-M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is the length of the initial bit sequence.

(185) In some embodiments, the predefined starting position may be selected in the following manner:

(186) When the code rate of the Polar encoding is greater than the predefined threshold, the starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(187) In some embodiments, the circular buffer includes a first part and a second part. The first part is composed of  $t_1$  continuous bits in the initial bit sequence in a sequential manner or in a BRO interleaving manner and the second part is composed of the remaining  $t_2$  bits in the initial bit sequence in the BRO interleaving manner, where  $t_1$  and  $t_2$  are both integers greater than or equal to 0,

(188)  $t_1 \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

$t_1+t_2=N$ ,  $N$  is a number of bits in the initial bit sequence, and  $N$  is an integer greater than or equal to 0.

(189) Alternatively, the first part is composed of  $t_2$  continuous bits in the initial bit sequence in the BRO interleaving manner and the second part is composed of the remaining  $t_1$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, where  $t_1$  and  $t_2$  are both integers greater than or equal to 0,

(190)  $t_1 \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

$t_1+t_2=N$ ,  $N$  is the number of bits in the initial bit sequence, and  $N$  is an integer greater than or equal to 0.

(191) The first part and the second part are sequentially arranged to form the bit sequence in the circular buffer.

(192) In some embodiments, the circular buffer includes a third part, a fourth part and a fifth part. The third part is composed of  $t_3$  continuous bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner or in a row-column interleaving manner; the fourth part is determined in the following manner: two continuous bit sequences of length  $t_4$  are selected from the initial bit sequence and arranged in the BRO interleaving manner or in the row-column interleaving manner or in an interlace manner; and the fifth part is composed of  $t_5$  bits in the initial bit sequence, where  $t_3$ ,  $t_4$  and  $t_5$  are all integers greater than or equal to 0,  $t_3+2\times t_4+t_5=N$ ,

(193)  $t_3 \in [\frac{1}{8}N, \frac{7}{8}N]$  and  $t_4 \in [\frac{1}{16}N, \frac{7}{16}N]$ .

(194) Alternatively, the third part is composed of  $t_5$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner or in the row-column interleaving manner; the fourth part is determined in the following manner: two continuous bit sequences of length  $t_4$  are selected from the initial bit sequence and arranged in the BRO interleaving

manner or in the row-column interleaving manner or in the interlace manner; and the fifth part is composed of the remaining  $t_3$  bits in the initial bit sequence, where  $t_3, t_4$  and  $t_5$  are all integers greater than or equal to 0,  $t_3+2\times t_4+t_5=N$ ,  
(195)  $0 \leq t_3 \in [\frac{1}{8}N, \frac{7}{8}N]$  and  $t_4 \in [\frac{1}{16}N, \frac{7}{16}N]$ .

(196) The third part, the fourth part and the fifth part are sequentially arranged to form the bit sequence in the circular buffer.

(197) In some embodiments, the predefined starting position is selected in one of the following manners:

(198) The starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(199) The position of  $P_{\text{sub}}=M-1$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}}$  represents the position index of the bit sequence in the circular buffer and  $M$  is the length of the bit sequence to be transmitted.

(200) The position of  $P_{\text{sub}}=N-M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is the length of the initial bit sequence.

(201) The ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(202) In some embodiments, the circular buffer includes a sixth part, a seventh part, an eighth part and a ninth part. The sixth part is composed of  $t_{\text{sub}.6}$  bits in the initial bit sequence in the BRO interleaving manner, the seventh part is composed of  $t_{\text{sub}.7}$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, the eighth part is composed of  $t_{\text{sub}.8}$  bits in the initial bit sequence in the BRO interleaving manner, and the ninth part is composed of  $t_{\text{sub}.9}$  bits in the initial bit sequence in the BRO interleaving manner, where  $t_{\text{sub}.6}, t_{\text{sub}.7}, t_{\text{sub}.8}$  and  $t_{\text{sub}.9}$  are all integers greater than or equal to 0,

(203)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N], (t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

and  $t_{\text{sub}.6}+t_{\text{sub}.7}+t_{\text{sub}.8}+t_{\text{sub}.9}=N$ .

(204) Alternatively, the sixth part is composed of  $t_{\text{sub}.9}$  bits in the initial bit sequence in the BRO interleaving manner, the seventh part is composed of  $t_{\text{sub}.8}$  bits in the initial bit sequence in the BRO interleaving manner, the eighth part is composed of  $t_{\text{sub}.7}$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, and the ninth part is composed of  $t_{\text{sub}.6}$  bits in the initial bit sequence in the BRO interleaving manner, where  $t_{\text{sub}.6}, t_{\text{sub}.7}, t_{\text{sub}.8}$  and  $t_{\text{sub}.9}$  are all integers greater than or equal to 0,

(205)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N], (t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

and  $t_{\text{sub}.6}+t_{\text{sub}.7}+t_{\text{sub}.8}+t_{\text{sub}.9}=N$ .

(206) In some embodiments, the circular buffer includes the sixth part, the seventh part, the eighth part and the ninth part. The sixth part is composed of  $t_{\text{sub}.6}$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, the seventh part is composed of  $t_{\text{sub}.7}$  bits in the initial bit sequence in the BRO interleaving manner, the eighth part is composed of  $t_{\text{sub}.8}$  bits in the initial bit sequence in the BRO interleaving manner, and the ninth part is composed of  $t_{\text{sub}.9}$  bits in the initial bit sequence in the BRO interleaving manner, where  $t_{\text{sub}.6}, t_{\text{sub}.7}, t_{\text{sub}.8}$  and  $t_{\text{sub}.9}$  are all integers greater than or equal to 0,

(207)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N], (t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

and  $t_{\text{sub}.6}+t_{\text{sub}.7}+t_{\text{sub}.8}+t_{\text{sub}.9}=N$ .

(208) Alternatively, the sixth part is composed of  $t_{\text{sub}.9}$  bits in the initial bit sequence in the BRO interleaving manner, the seventh part is composed of  $t_{\text{sub}.8}$  bits in the initial bit sequence in the BRO interleaving manner, the eighth part is composed of  $t_{\text{sub}.7}$  bits in the initial bit sequence in the BRO interleaving manner, and the ninth part is composed of  $t_{\text{sub}.6}$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, where  $t_{\text{sub}.6}, t_{\text{sub}.7}, t_{\text{sub}.8}$  and  $t_{\text{sub}.9}$  are all integers greater than or equal to 0,

(209)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N], (t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

and  $t_{\text{sub}.6}+t_{\text{sub}.7}+t_{\text{sub}.8}+t_{\text{sub}.9}=N$ .

(210) In some embodiments, a mother code of the Polar code has a length of  $N=2^{\lceil \log_2(K/R) \rceil + m}$ , where  $\lceil \cdot \rceil$  represents a ceiling operation,  $R$  is a code rate, and  $m$  is a positive integer.

(211) In some embodiments, the bit sequence in the circular buffer is obtained by performing BRO interleaving on the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$ , and a bit  $S_n$  with a bit position index  $n$  in the initial bit sequence is mapped onto a position with a position index  $\text{mod}(\text{BRO}(n)+m, N)$  in the circular buffer by means of a BRO interleaver, where  $n=0, 1, \dots, N-1, m=0, 1, \dots, N-1, m$  is an offset and  $\text{mod}(x_1, x_2)$  represents a remainder of a division  $x_1/x_2$ .

(212) In some embodiments, the bit sequence in the circular buffer is obtained by performing the BRO interleaving on the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$ , and the bit  $S_n$  with the bit position index  $n$  in the initial bit sequence is mapped onto a position with a position index  $N-1-\text{mod}(\text{BRO}(n)+m, N)$  in the circular buffer by means of the BRO interleaver, where  $n=0, 1, \dots, N-1, m=0, 1, \dots, N-1, m$  is the offset and  $\text{mod}(x_1, x_2)$  represents the remainder of the division  $x_1/x_2$ .

(213) In some embodiments, the processor is further configured to perform, according to the instructions stored in the memory, the following operations: the predefined rule for the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  is determined by a one-to-one mapping interleaving function  $f(n)$  generated according to a data characteristic of the Polar code, where  $n=0, 1, \dots, N-1, f(n)=0, 1, \dots, N-1, n$  is a bit position index in the initial bit sequence, and  $f(n)$  is a position index in the circular buffer; and a bit  $S_n$  with a bit position index  $n$  in the initial bit sequence is mapped onto a

position with a position index  $f(n)$  in the circular buffer according to the one-to-one mapping interleaving function  $f(n)$ .  
(214) In some embodiments, the predefined rule may be determined by a one-to-one mapping interleaving function  $p(n)$  generated according to the data characteristic of the Polar code, where  $n=0, 1, \dots, N-1$ ,  $p(n)=0, 1, \dots, N-1$ ,  $p(n)$  is a bit position index in the initial bit sequence, and  $n$  is a position index in the circular buffer. The operation of selecting the bits from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in the non-repeated manner and writing the bits into the  $q$  parts of the circular buffer according to the predefined rule includes: mapping a bit  $S_{\text{sub}.p(n)}$  with a bit position index  $p(n)$  in the initial bit sequence onto a position with a position index  $n$  in the circular buffer according to the one-to-one mapping interleaving function  $p(n)$ .

(215) In some embodiments, the one-to-one mapping interleaving function  $f(n)$  has the following nesting characteristic: a mapping  $\{n_{\text{sub}.0}\}_{\text{sub}.fwdarw.\{f(n_{\text{sub}.0})\}}$  may be directly obtained by deleting an element greater than  $N_{\text{sub}.0}$  from a sequence  $\{n\}$  and a sequence  $\{f(n)\}$  in the mapping  $\{n\}_{\text{sub}.fwdarw.\{f(n)\}}$  of the one-to-one mapping interleaving function, where  $n_{\text{sub}.0}=0, 1, 2, \dots, N_{\text{sub}.0}-1$  and  $N_{\text{sub}.0}$  is a positive integer less than or equal to  $N$ .

(216) In some embodiments, the predefined rule for the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  may be performed by mapping the bit  $S_{\text{sub}.n}$  with the bit position index  $n$  in the initial bit sequence onto a position with a position index  $\text{mod}(f(n)+m, N)$  in the circular buffer according to the data characteristic of the Polar code, where  $m=0, 1, \dots, N-1$ ,  $m$  is an offset and  $\text{mod}(x_{\text{sub}.1}, x_{\text{sub}.2})$  represents a remainder of a division  $x_{\text{sub}.1}/x_{\text{sub}.2}$ , where  $x_{\text{sub}.1}$  is an integer and  $x_{\text{sub}.2}$  is a positive integer.

(217) In some embodiments, the predefined starting position is selected in one of the following manners:

(218) A starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(219) A position of  $P_{\text{sub}.0}=M-1$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents a position index of the bit sequence in the circular buffer and  $M$  is a length of the bit sequence to be transmitted.

(220) A position of  $P_{\text{sub}.0}=N-M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is a length of the initial bit sequence.

(221) An ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(222) In some embodiments, the predefined starting position is selected according to a code rate of the Polar encoding.

(223) In some embodiments, the predefined starting position may be selected in the following manner:

(224) When the code rate of the Polar encoding is less than or equal to a predefined threshold, the position of  $P_{\text{sub}.0}=N-M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is the length of the initial bit sequence.

(225) The predefined starting position may be selected in the following manner:

(226) When the code rate of the Polar encoding is greater than the predefined threshold, the starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(227) In some embodiments, the circular buffer includes a first part and a second part. The first part is composed of  $t_1$  continuous bits in the initial bit sequence in a sequential manner or in a BRO interleaving manner and the second part is composed of the remaining  $t_2$  bits in the initial bit sequence in the BRO interleaving manner, where  $t_1$  and  $t_2$  are both integers greater than or equal to 0,

(228)  $t_1 \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

$t_1+t_2=N$ ,  $N$  is a number of bits in the initial bit sequence, and  $N$  is an integer greater than or equal to 0.

(229) Alternatively, the first part is composed of  $t_2$  continuous bits in the initial bit sequence in the BRO interleaving manner and the second part is composed of the remaining  $t_1$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, where  $t_1$  and  $t_2$  are both integers greater than or equal to 0,

(230)  $t_1 \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

$t_1+t_2=N$ ,  $N$  is the number of bits in the initial bit sequence, and  $N$  is an integer greater than or equal to 0.

(231) The first part and the second part are sequentially arranged to form the bit sequence in the circular buffer.

(232) In some embodiments, the circular buffer includes a third part, a fourth part and a fifth part. The third part is composed of  $t_3$  continuous bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner or in a row-column interleaving manner; the fourth part is determined in the following manner: two continuous bit sequences of length  $t_4$  are selected from the initial bit sequence and arranged in the BRO interleaving manner or in the row-column interleaving manner or in an interlace manner; and the fifth part is composed of  $t_5$  bits in the initial bit sequence, where  $t_3$ ,  $t_4$  and  $t_5$  are all integers greater than or equal to 0,  $t_3+2\times t_4+t_5=N$ ,

(233)  $t_3 \in [\frac{1}{8}N, \frac{7}{8}N]$  and  $t_4 \in [\frac{1}{16}N, \frac{7}{16}N]$ .

(234) Alternatively, the third part is composed of  $t_5$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner or in the row-column interleaving manner; the fourth part is determined in the following manner: two continuous bit sequences of length  $t_4$  are selected from the initial bit sequence and arranged in the BRO interleaving manner or in the row-column interleaving manner or in the interlace manner; and the fifth part is composed of the remaining  $t_3$  bits in the initial bit sequence, where  $t_3$ ,  $t_4$  and  $t_5$  are all integers greater than or equal to 0,  $t_3+2\times t_4+t_5=N$ ,

(235)  $t_3 \in [\frac{1}{8}N, \frac{7}{8}N]$  and  $t_4 \in [\frac{1}{16}N, \frac{7}{16}N]$ .

(236) The third part, the fourth part and the fifth part are sequentially arranged to form the bit sequence in the circular

buffer.

(237) In some embodiments, the predefined starting position is selected in one of the following manners:

(238) The starting bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(239) The position of  $P_{\text{sub}.0} = M - 1$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer and  $M$  is the length of the bit sequence to be transmitted.

(240) The position of  $P_{\text{sub}.0} = N - M$  in the circular buffer is taken as the predefined starting position, where  $P_{\text{sub}.0}$  represents the position index of the bit sequence in the circular buffer,  $M$  is the length of the bit sequence to be transmitted, and  $N$  is the length of the initial bit sequence.

(241) The ending bit position of the bit sequence in the circular buffer is taken as the predefined starting position.

(242) In some embodiments, the circular buffer includes a sixth part, a seventh part, an eighth part and a ninth part. The sixth part is composed of  $t_{\text{sub}.6}$  bits in the initial bit sequence in the BRO interleaving manner, the seventh part is composed of  $t_{\text{sub}.7}$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, the eighth part is composed of  $t_{\text{sub}.8}$  bits in the initial bit sequence in the BRO interleaving manner, and the ninth part is composed of  $t_{\text{sub}.9}$  bits in the initial bit sequence in the BRO interleaving manner, where  $t_{\text{sub}.6}$ ,  $t_{\text{sub}.7}$ ,  $t_{\text{sub}.8}$  and  $t_{\text{sub}.9}$  are all integers greater than or equal to 0,

(243)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,  $(t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

and  $t_{\text{sub}.6} + t_{\text{sub}.7} + t_{\text{sub}.8} + t_{\text{sub}.9} = N$ .

(244) Alternatively, the sixth part is composed of  $t_{\text{sub}.9}$  bits in the initial bit sequence in the BRO interleaving manner, the seventh part is composed of  $t_{\text{sub}.8}$  bits in the initial bit sequence in the BRO interleaving manner, the eighth part is composed of  $t_{\text{sub}.7}$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, and the ninth part is composed of  $t_{\text{sub}.6}$  bits in the initial bit sequence in the BRO interleaving manner, where  $t_{\text{sub}.6}$ ,  $t_{\text{sub}.7}$ ,  $t_{\text{sub}.8}$  and  $t_{\text{sub}.9}$  are all integers greater than or equal to 0,

(245)  $0(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,  $(t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

and  $t_{\text{sub}.6} + t_{\text{sub}.7} + t_{\text{sub}.8} + t_{\text{sub}.9} = N$ .

(246) In some embodiments, the circular buffer includes the sixth part, the seventh part, the eighth part and the ninth part. The sixth part is composed of  $t_{\text{sub}.6}$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, the seventh part is composed of  $t_{\text{sub}.7}$  bits in the initial bit sequence in the BRO interleaving manner, the eighth part is composed of  $t_{\text{sub}.8}$  bits in the initial bit sequence in the BRO interleaving manner, and the ninth part is composed of  $t_{\text{sub}.9}$  bits in the initial bit sequence in the BRO interleaving manner, where  $t_{\text{sub}.6}$ ,  $t_{\text{sub}.7}$ ,  $t_{\text{sub}.8}$  and  $t_{\text{sub}.9}$  are all integers greater than or equal to 0,

(247)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,  $(t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

and  $t_{\text{sub}.6} + t_{\text{sub}.7} + t_{\text{sub}.8} + t_{\text{sub}.9} = N$ .

(248) Alternatively, the sixth part is composed of  $t_{\text{sub}.9}$  bits in the initial bit sequence in the BRO interleaving manner, the seventh part is composed of  $t_{\text{sub}.8}$  bits in the initial bit sequence in the BRO interleaving manner, the eighth part is composed of  $t_{\text{sub}.7}$  bits in the initial bit sequence in the BRO interleaving manner, and the ninth part is composed of  $t_{\text{sub}.6}$  bits in the initial bit sequence in the sequential manner or in the BRO interleaving manner, where  $t_{\text{sub}.6}$ ,  $t_{\text{sub}.7}$ ,  $t_{\text{sub}.8}$  and  $t_{\text{sub}.9}$  are all integers greater than or equal to 0,

(249)  $(t_6 + t_7) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,  $(t_8 + t_9) \in [\frac{1}{8}N, \frac{7}{8}N]$ ,

and  $t_{\text{sub}.6} + t_{\text{sub}.7} + t_{\text{sub}.8} + t_{\text{sub}.9} = N$ .

(250) In some embodiments, a mother code of the Polar code has a length of  $N = 2^{\lceil \log_2(K/R) \rceil + m}$ , where  $\lceil \cdot \rceil$  represents a ceiling operation,  $R$  is a code rate, and  $m$  is a positive integer.

(251) In some embodiments, the bit sequence in the circular buffer is obtained by performing BRO interleaving on the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$ , and a bit  $S_n$  with a bit position index  $n$  in the initial bit sequence is mapped onto a position with a position index  $\text{mod}(\text{BRO}(n) + m, N)$  in the circular buffer by means of a BRO interleaver, where  $n = 0, 1, \dots, N-1$ ,  $m = 0, 1, \dots, N-1$ ,  $m$  is an offset and  $\text{mod}(x_1, x_2)$  represents a remainder of a division  $x_1/x_2$ .

(252) In some embodiments, the bit sequence in the circular buffer is obtained by performing the BRO interleaving on the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$ , and the bit  $S_n$  with the bit position index  $n$  in the initial bit sequence is mapped onto a position with a position index  $N - 1 - \text{mod}(\text{BRO}(n) + m, N)$  in the circular buffer by means of the BRO interleaver, where  $n = 0, 1, \dots, N-1$ ,  $m = 0, 1, \dots, N-1$ ,  $m$  is the offset and  $\text{mod}(x_1, x_2)$  represents the remainder of the division  $x_1/x_2$ .

(253) Examples are given below to illustrate the processing methods and implementation modes in the embodiments described above in this embodiment.

Example 1

(254) 1. Polar code is performed on an information bit sequence of length  $K = 4$  using code rate  $R = \frac{2}{3}$ , and a length of the encoded bit sequence is  $N = 2^{\lceil \log_2(K/R) \rceil} = 2^{\lceil \log_2(4 \times 3/2) \rceil} = 8$ . 2. A mapping function for mapping the initial bit sequence is determined by a BRO operation (which is not limited herein) to obtain the bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.4}, S_{\text{sub}.2}, S_{\text{sub}.6}, S_{\text{sub}.1}, S_{\text{sub}.5}, S_{\text{sub}.3}, S_{\text{sub}.7}\}$  in the circular buffer. 3. Six bits  $\{S_{\text{sub}.0}, S_{\text{sub}.4}, S_{\text{sub}.2}, S_{\text{sub}.6}, S_{\text{sub}.1}, S_{\text{sub}.5}\}$  are read in an ascending order of indexes from a starting position in the circular buffer. 4. The six data bits  $\{S_{\text{sub}.0}, S_{\text{sub}.4}, S_{\text{sub}.2}, S_{\text{sub}.6}, S_{\text{sub}.1}, S_{\text{sub}.5}\}$  are sequentially arranged and

transmitted as a rate matching data bit sequence to be transmitted.

#### Example 2

(255) Step 1 and step 2 are the same as those in the example 1. 3. Six bits

{S.sub.5,S.sub.1,S.sub.6,S.sub.2,S.sub.4,S.sub.0} are read in a descending order of indexes from a position with a position index  $P0=M-1=5$  in the circular buffer. 4. The six data bits {S.sub.5,S.sub.1,S.sub.6,S.sub.2,S.sub.4,S.sub.0} are reversely arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 3

(256) Step 1 and step 2 are the same as those in the example 1. 3. Six bits

{S.sub.2,S.sub.6,S.sub.1,S.sub.5,S.sub.3,S.sub.7} are read in the ascending order of indexes from a position with a position index  $P0=N-M=2$  in the circular buffer. 4. The six data bits {S.sub.2,S.sub.6,S.sub.1,S.sub.5,S.sub.3,S.sub.7} are sequentially arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 4

(257) Step 1 and step 2 are the same as those in the example 1. 3. Six bits

{S.sub.7,S.sub.3,S.sub.5,S.sub.1,S.sub.6,S.sub.2} are read in the descending order of indexes from an ending position in the circular buffer. 4. The six data bits {S.sub.7,S.sub.3,S.sub.5,S.sub.1,S.sub.6,S.sub.2} are reversely arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 5

(258) Step 1 is the same as that in the example 1. 2. The bit sequence in the circular buffer obtained in the example 1 is reversely arranged to obtain {S.sub.7,S.sub.3,S.sub.5,S.sub.1,S.sub.6,S.sub.2,S.sub.4,S.sub.0}.

(259) Step 3 and step 4 are the same as those in the example 1.

#### Example 6

(260) Step 1 and step 2 are the same as those in the example 5.

(261) Step 3 and step 4 are the same as those in the example 2.

#### Example 7

(262) Step 1 and step 2 are the same as those in the example 5.

(263) Step 3 and step 4 are the same as those in the example 3.

#### Example 8

(264) Step 1 and step 2 are the same as those in the example 5.

(265) Step 3 and step 4 are the same as those in the example 4.

#### Example 9

(266) 1. The Polar code is performed on an information bit sequence of length  $K=2$  using code rate  $R=2/3$ , and the length of the encoded bit sequence is  $N=2 \cdot \lceil \log_2(K/R) \rceil = 2 \cdot \lceil \log_2(2 \times 3/2) \rceil = 4$ . 2. According to a BRO nesting characteristic of the mapping function of the initial bit sequence, elements with position indexes greater than or equal to 4 may be directly deleted from the bit sequence in the circular buffer in the example 1 to obtain the bit sequence {S.sub.0,S.sub.2,S.sub.1,S.sub.3} in the circular buffer. 3. Three bits {S.sub.0,S.sub.2,S.sub.1} are read in the ascending order of indexes from the starting position in the circular buffer. 4. The three data bits {S.sub.0,S.sub.2,S.sub.1} are sequentially arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 10

(267) Step 1 and step 2 are the same as those in the example 9. 3. Three bits {S.sub.1,S.sub.2,S.sub.0} are read in the descending order of indexes from a position with a position index  $P0=M-1=2$  in the circular buffer. 4. The three data bits {S.sub.1,S.sub.2,S.sub.0} are reversely arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 11

(268) Step 1 and step 2 are the same as those in the example 9. 3. Three bits {S.sub.2,S.sub.1,S.sub.3} are read in the ascending order of indexes from a position with a position index  $P0=N-M=1$  in the circular buffer. 4. The three data bits {S.sub.2,S.sub.1,S.sub.3} are sequentially arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 12

(269) Step 1 and step 2 are the same as those in the example 9. 3. Three bits {S.sub.3,S.sub.1,S.sub.2} are read in the descending order of indexes from the ending position in the circular buffer. 4. The three data bits {S.sub.3,S.sub.1,S.sub.2} are reversely arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 13

(270) Step 1 is the same as that in the example 9. 2. The bit sequence in the circular buffer obtained in the example 9 is reversely arranged to obtain {S.sub.3,S.sub.1,S.sub.2,S.sub.0}.

(271) Step 3 and step 4 are the same as those in the example 9.

#### Example 14

(272) Step 1 and step 2 are the same as those in the example 13.

(273) Step 3 and step 4 are the same as those in the example 10.

#### Example 15

(274) Step 1 and step 2 are the same as those in the example 13.

(275) Step 3 and step 4 are the same as those in the example 11.

#### Example 16

(276) Step 1 and step 2 are the same as those in the example 13.

(277) Step 3 and step 4 are the same as those in the example 12.

(278) The cases where the bit sequence in the circular buffer is divided into two parts are described below.

#### Example 17

(279) The rate matching method for the circular buffer of the Polar code includes the steps described below. 1. The Polar code is performed on an information bit sequence of length  $K=8$  using code rate  $R=1/3$ , and the length of the encoded bit sequence is  $N=2 \cdot \lceil \log_2(K/R) \rceil = 2 \cdot \lceil \log_2(8 \times 3) \rceil = 32$ . 2. A part 1 of the circular buffer is composed of 6 continuous bits  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.5}\}$  in the encoded bit sequence; a part 2 of the circular buffer is composed of the continuous bits  $\{S_{\text{sub}.6}, S_{\text{sub}.7}, \dots, S_{\text{sub}.31}\}$  in the encoded bit sequence in the BRO interleaving manner and thus a bit sequence in the part 2 is arranged as  $\{S_{\text{sub}.16}, S_{\text{sub}.8}, S_{\text{sub}.24}, S_{\text{sub}.20}, S_{\text{sub}.12}, S_{\text{sub}.28}, S_{\text{sub}.18}, S_{\text{sub}.10}, S_{\text{sub}.26}, S_{\text{sub}.6}, S_{\text{sub}.22}, S_{\text{sub}.14}, S_{\text{sub}.30}, S_{\text{sub}.17}, S_{\text{sub}.9}, S_{\text{sub}.25}, S_{\text{sub}.21}, S_{\text{sub}.13}, S_{\text{sub}.29}, S_{\text{sub}.19}, S_{\text{sub}.11}, S_{\text{sub}.27}, S_{\text{sub}.7}, S_{\text{sub}.23}, S_{\text{sub}.15}, S_{\text{sub}.31}\}$ . 3. 24 bits are read in the ascending order of indexes from a bit position with a position index  $P_{\text{sub}.0} = N - M = N - K/R = 32 - 24 = 8$  in the circular buffer. 4. The 24 data bits are sequentially arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 18

(280) The rate matching method for the circular buffer of the Polar code includes the steps described below.

(281) Step 1 and step 2 are the same as those in the example 17. 3. 24 bits are read in the descending order of indexes from the ending bit position in the circular buffer. 4. The 24 data bits are reversely arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 19

(282) The rate matching method for the circular buffer of the Polar code includes the steps described below. 1. The Polar code is performed on an information bit sequence of length  $K=8$  using code rate  $R=1/3$ , and the length of the encoded bit sequence is  $N=2 \cdot \lceil \log_2(K/R) \rceil = 2 \cdot \lceil \log_2(8 \times 3) \rceil = 32$ . 2. The part 1 of the circular buffer is composed of 26 continuous bits  $\{S_{\text{sub}.31}, S_{\text{sub}.30}, \dots, S_{\text{sub}.7}\}$  in the encoded bit sequence in the BRO interleaving manner; the part 2 of the circular buffer is composed of 6 continuous bits  $\{S_{\text{sub}.5}, S_{\text{sub}.4}, \dots, S_{\text{sub}.0}\}$  in the encoded bit sequence in the sequential manner. 3. 24 bits are read in the ascending order of indexes from the starting position in the circular buffer. 4. The 24 data bits in a bit sequence read from the circular buffer are reversely arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 20

(283) The rate matching method for the circular buffer of the Polar code includes the steps described below.

(284) Step 1 and step 2 are the same as those in the example 17. 3. 24 bits are read in the descending order of indexes from a bit position with a position index  $P_{\text{sub}.0} = M - 1 = K/R - 1 = 24 - 1 = 23$  in the circular buffer. 4. The 24 data bits in the bit sequence read from the circular buffer are sequentially arranged and transmitted as the rate matching data bit sequence to be transmitted.

(285) The cases where the bit sequence in the circular buffer is divided into three parts are described below.

#### Example 21

(286) The rate matching method for the circular buffer of the Polar code includes the steps described below. 1. The Polar code is performed on an information bit sequence of length  $K=64$  using code rate  $R=1/3$ , and the length of the encoded bit sequence is  $N=2 \cdot \lceil \log_2(K/R) \rceil = 2 \cdot \lceil \log_2(64 \times 3) \rceil = 256$ . 2. A part 3 of the circular buffer is composed of 64 continuous bits  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.63}\}$  in the encoded bit sequence in the sequential manner; a part 4 of the circular buffer is composed of 64 bits  $\{S_{\text{sub}.64}, S_{\text{sub}.65}, \dots, S_{\text{sub}.127}\}$  and 64 bits  $\{S_{\text{sub}.128}, S_{\text{sub}.129}, \dots, S_{\text{sub}.191}\}$  in the encoded bit sequence in the interlace manner, which means that the part 4 is composed of bits  $\{S_{\text{sub}.64}, S_{\text{sub}.128}, S_{\text{sub}.65}, S_{\text{sub}.129}, \dots, S_{\text{sub}.127}, S_{\text{sub}.191}\}$ ; a part 5 of the circular buffer is composed of 64 continuous bits  $\{S_{\text{sub}.192}, S_{\text{sub}.193}, \dots, S_{\text{sub}.255}\}$  in the encoded bit sequence in the sequential manner. Therefore, the bit sequence in the circular buffer is  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.63}, S_{\text{sub}.64}, S_{\text{sub}.128}, S_{\text{sub}.65}, S_{\text{sub}.129}, \dots, S_{\text{sub}.127}, S_{\text{sub}.191}, S_{\text{sub}.192}, S_{\text{sub}.193}, \dots, S_{\text{sub}.255}\}$ . 3. 192 bits are read in the ascending order of indexes from a bit position with a position index  $P_{\text{sub}.0} = N - M = N - K/R = 256 - 192 = 64$  in the circular buffer. 4. The 192 data bits are sequentially arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 22

(287) The rate matching method for the circular buffer of the Polar code includes the steps described below.

(288) Step 1 and step 2 are the same as those in the example 21. 3. 192 bits are read in the descending order of indexes from the ending bit position in the circular buffer. 4. The 192 data bits are reversely arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 23

(289) The rate matching method for the circular buffer of the Polar code includes the steps described below. 1. The Polar code is performed on the information bit sequence of length  $K=64$  using code rate  $R=1/3$ , and the length of the encoded bit sequence is  $N=2 \cdot \lceil \log_2(K/R) \rceil = 2 \cdot \lceil \log_2(64 \times 3) \rceil = 256$ . 2. The part 3 of the circular buffer is composed of 64 continuous bits  $\{S_{\text{sub}.255}, S_{\text{sub}.254}, \dots, S_{\text{sub}.192}\}$  in the encoded bit sequence in the sequential manner; the part 4 of the circular buffer is composed of 64 bits  $\{S_{\text{sub}.191}, S_{\text{sub}.190}, \dots, S_{\text{sub}.128}\}$  and 64 bits

{S.sub.127, S.sub.126, . . . , S.sub.64} in the encoded bit sequence in the interlace manner, which means that the part 4 is composed of bits {S.sub.191, S.sub.127, S.sub.190, S.sub.126, . . . , S.sub.128, S.sub.64}; the part 5 of the circular buffer is composed of 64 continuous bits {S.sub.63, S.sub.62, . . . , S.sub.0} in the encoded bit sequence in the sequential manner. Therefore, the bit sequence in the circular buffer is {S.sub.255, S.sub.254, . . . , S.sub.192, S.sub.191, S.sub.127, S.sub.190, S.sub.126, . . . , S.sub.128, S.sub.64, S.sub.63, S.sub.62, . . . , S.sub.0}. 3. 192 bits are read in the ascending order of indexes from the starting position in the circular buffer. 4. The 192 data bits in a bit sequence read from the circular buffer are reversely arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 24

(290) The rate matching method for the circular buffer of the Polar code includes the steps described below.

(291) Step 1 and step 2 are the same as those in the example 23. 3. 192 bits are read in the descending order of indexes from a bit position with a position index  $P_{sub.0} = M - 1 = K/R - 1 = 192 - 1 = 191$  in the circular buffer. 4. The 192 data bits in the bit sequence read from the circular buffer are sequentially arranged and transmitted as the rate matching data bit sequence to be transmitted.

(292) The cases where the bit sequence in the circular buffer is divided into four parts are described below.

#### Example 25

(293) 1. The Polar code is performed on an information bit sequence of length  $K=9$  using code rate  $R=1/2$ , and the length of the encoded bit sequence is  $N=2^{\lceil \log_2(K/R) \rceil} = 2^{\lceil \log_2(9 \times 2) \rceil} = 32$ . 2. A bit sequence set is defined as  $\{S_{sub.BRO(j)}\} = \{S_{sub.9}, S_{sub.25}, S_{sub.5}, S_{sub.21}, S_{sub.13}, S_{sub.29}, S_{sub.3}, S_{sub.19}, S_{sub.11}, S_{sub.27}, S_{sub.7}, S_{sub.23}, S_{sub.15}, S_{sub.31}\}$ . A part 6 {I.sub.1} of the circular buffer includes an intersection of  $\{S_{sub.0}, S_{sub.1}, \dots, S_{sub.5}\}$  and  $\{S_{sub.BRO(j)}\}$  and is arranged in the BRO interleaving manner as  $\{I_{sub.1}\} = \{S_{sub.5}, S_{sub.3}\}$ , where  $j=18, \dots, 31$ . A part 7 {I.sub.2} of the circular buffer is a difference set of  $\{S_{sub.0}, S_{sub.1}, \dots, S_{sub.5}\}$  and  $\{I_{sub.1}\}$  and is arranged in the sequential manner as  $\{I_{sub.2}\} = \{S_{sub.0}, S_{sub.1}, S_{sub.2}, S_{sub.4}\}$ . A part 9 {I.sub.4} of the circular buffer includes an intersection of  $\{S_{sub.6}, S_{sub.7}, \dots, S_{sub.31}\}$  and  $\{S_{sub.BRO(j)}\}$  and is arranged in the BRO interleaving manner as  $\{I_{sub.4}\} = \{S_{sub.9}, S_{sub.25}, S_{sub.21}, S_{sub.13}, S_{sub.29}, S_{sub.19}, S_{sub.11}, S_{sub.27}, S_{sub.7}, S_{sub.23}, S_{sub.15}, S_{sub.31}\}$ . A part 8 {S.sub.i.sub.3} of the circular buffer is a difference set of  $\{S_{sub.6}, S_{sub.7}, \dots, S_{sub.31}\}$  and  $\{S_{sub.i.sub.4}\}$  and is arranged in the BRO interleaving manner as  $\{I_{sub.3}\} = \{S_{sub.16}, S_{sub.8}, S_{sub.24}, S_{sub.20}, S_{sub.12}, S_{sub.28}, S_{sub.18}, S_{sub.10}, S_{sub.26}, S_{sub.6}, S_{sub.22}, S_{sub.14}, S_{sub.30}, S_{sub.17}\}$ . Therefore, the bit sequence in the circular buffer is {S.sub.5, S.sub.3, S.sub.0, S.sub.1, S.sub.2, S.sub.4, S.sub.16, S.sub.8, S.sub.24, S.sub.20, S.sub.12, S.sub.28, S.sub.18, S.sub.10, S.sub.26, S.sub.6, S.sub.22, S.sub.14, S.sub.30, S.sub.17, S.sub.9, S.sub.25, S.sub.21, S.sub.13, S.sub.29, S.sub.19, S.sub.11, S.sub.27, S.sub.7, S.sub.23, S.sub.15, S.sub.31}. 3. If  $R=1/2$  is greater than the predefined threshold, 18 bits are read in the ascending order of indexes from a starting position of the part 7 in the circular buffer; if  $R=1/2$  is less than the predefined threshold, 18 bits are read in the ascending order of indexes from a position with a position index  $P_{sub.0} = N - M = 14$  in the circular buffer. 4. The 18 data bits in the bit sequence read from the circular buffer are sequentially arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 26

(294) Step 1 and step 2 are the same as those in the example 25. 3. If  $R=1/2$  is greater than the predefined threshold, 18 bits are read in the descending order of indexes from an ending position of the part 8 in the circular buffer; if  $R=1/2$  is less than the predefined threshold, 18 bits are read in the descending order of indexes from the ending position in the circular buffer. 4. The 18 data bits in a bit sequence read from the circular buffer are reversely arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 27

(295) The step 1 is the same as that in the example 25. 2. The bit sequence in the circular buffer obtained in the example 25 is reversely arranged to obtain {S.sub.31, S.sub.15, S.sub.23, S.sub.7, S.sub.27, S.sub.11, S.sub.19, S.sub.29, S.sub.13, S.sub.21, S.sub.25, S.sub.9, S.sub.17, S.sub.30, S.sub.14, S.sub.22, S.sub.6, S.sub.26, S.sub.10, S.sub.18, S.sub.28, S.sub.12, S.sub.20, S.sub.24, S.sub.8, S.sub.16, S.sub.4, S.sub.2, S.sub.1, S.sub.0, S.sub.3, S.sub.5}. 3. If  $R=1/2$  is greater than the predefined threshold, 18 bits are read in the ascending order of indexes from the starting position of the part 7 in the circular buffer; if  $R=1/2$  is less than the predefined threshold, 18 bits are read in the ascending order of indexes from the starting position in the circular buffer. 4. The 18 data bits in the bit sequence read from the circular buffer are sequentially arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 28

(296) Step 1 and step 2 are the same as those in the example 27. 3. If  $R=1/2$  is greater than the predefined threshold, 18 bits are read in the descending order of indexes from the ending position of the part 8 in the circular buffer; if  $R=1/2$  is less than the predefined threshold, 18 bits are read in the descending order of indexes from a position with a position index  $P_{sub.0} = M - 1 = 17$  in the circular buffer. 4. The 18 data bits in a bit sequence read from the circular buffer are reversely arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 29

(297) Step 1 is the same as that in the example 25. 2. The part 6 of the circular buffer is  $\{I_{sub.1}\} = \{S_{sub.0}, S_{sub.1}, S_{sub.2}, S_{sub.4}\}$ , the part 7 is  $\{I_{sub.2}\} = \{S_{sub.5}, S_{sub.3}\}$ , the part 8 is  $\{I_{sub.3}\} = \{S_{sub.9}, S_{sub.25}, S_{sub.21}, S_{sub.13}, S_{sub.29}, S_{sub.19}, S_{sub.11}, S_{sub.27}, S_{sub.7}, S_{sub.23}, S_{sub.15}, S_{sub.31}\}$  and the

part 9 is {I.sub.1} =

{S.sub.16,S.sub.8,S.sub.24,S.sub.20,S.sub.12,S.sub.28,S.sub.18,S.sub.10,S.sub.26,S.sub.6,S.sub.22,S.sub.14,S.sub.30,S.sub.17}

Therefore, the bit sequence in the circular buffer is {S.sub.0, S.sub.1, S.sub.2, S.sub.4, S.sub.5, S.sub.3, S.sub.9, S.sub.25, S.sub.21, S.sub.13, S.sub.29, S.sub.19, S.sub.11, S.sub.27, S.sub.7, S.sub.23, S.sub.15, S.sub.31, S.sub.16, S.sub.8, S.sub.24, S.sub.20, S.sub.12, S.sub.28, S.sub.18, S.sub.10, S.sub.26, S.sub.6, S.sub.22, S.sub.14, S.sub.30, S.sub.17}. 3. If  $R=\frac{1}{2}$  is greater than the predefined threshold, 18 bits are read in the ascending order of indexes from a starting position of the part 9 in the circular buffer. If the reading goes to the ending position in the circular buffer, the reading is continued from the starting position in the circular buffer until the reading of 18 bits is completed. If  $R=\frac{1}{2}$  is less than the predefined threshold, 18 bits are read in the ascending order of indexes from the starting position of the part 8 in the circular buffer. If the reading goes to the ending position in the circular buffer, the reading is continued from the starting position in the circular buffer until the reading of 18 bits is completed. 4. The 18 data bits in the bit sequence read from the circular buffer are sequentially arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 30

(298) Step 1 and step 2 are the same as those in the example 29. 3. If  $R=\frac{1}{2}$  is greater than the predefined threshold, 18 bits are read in the descending order of indexes from an ending position of the part 6 in the circular buffer. If the reading goes to the starting position in the circular buffer, the reading is continued from the ending position in the circular buffer until the reading of 18 bits is completed. If  $R=\frac{1}{2}$  is less than the predefined threshold, 18 bits are read in the descending order of indexes from a position with a position index P.sub.0=23 in the circular buffer. 4. The 18 data bits in a bit sequence read from the circular buffer are reversely arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 31

(299) Step 1 is the same as that in the example 29. 2. The bit sequence in the circular buffer is obtained by reversely arranging the bit sequence in the example 29. 3. If  $R=\frac{1}{2}$  is greater than the predefined threshold, 18 bits are read in the ascending order of indexes from the starting position of the part 9 in the circular buffer. If the reading goes to the ending position in the circular buffer, the reading is continued from the starting position in the circular buffer until the reading of 18 bits is completed. If  $R=\frac{1}{2}$  is less than the predefined threshold, 18 bits are read in the ascending order of indexes from a position with a position index P.sub.0=8 in the circular buffer. 4. The 18 data bits in the bit sequence read from the circular buffer are sequentially arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 32

(300) Step 1 and step 2 are the same as those in the example 31. 3. If  $R=\frac{1}{2}$  is greater than the predefined threshold, 18 bits are read in the descending order of indexes from the ending position of the part 6 in the circular buffer. If the reading goes to the starting position in the circular buffer, the reading is continued from the ending position in the circular buffer until the reading of 18 bits is completed. If  $R=\frac{1}{2}$  is less than the predefined threshold, 18 bits are read in the descending order of indexes from an ending position of the part 7 in the circular buffer. 4. The 18 data bits in a bit sequence read from the circular buffer are reversely arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 33

(301) 1. The Polar code is performed on the information bit sequence of length  $K=2$  using code rate  $R=\frac{2}{3}$ , and the length of the encoded bit sequence is  $N=2.\sup.\lceil\log.\sup.2.\sup.(K/R)\rceil+m=2.\sup.\lceil\log.\sup.2.\sup.(2\times3/2)\rceil+1=8$ . At this time,  $m=1$ , but  $m$  is not limited to 1. 2. The BRO interleaving is performed on the initial bit sequence according to its mapping function to obtain the bit sequence {S.sub.0,S.sub.4,S.sub.2,S.sub.6,S.sub.1,S.sub.3,S.sub.3,S.sub.7} in the circular buffer. 3. Three bits {S.sub.0,S.sub.4,S.sub.2} are read in the ascending order of indexes from the starting position in the circular buffer. 4. The three data bits {S.sub.0,S.sub.4,S.sub.2} are sequentially arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 34

(302) Step 1 and step 2 are the same as those in the example 33. 3. Three bits {S.sub.2,S.sub.4,S.sub.0} are read in the descending order of indexes from a position with a position index  $P_0=M-1=2$  in the circular buffer. 4. The three data bits {S.sub.2,S.sub.4,S.sub.0} are reversely arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 35

(303) Step 1 and step 2 are the same as those in the example 33. 3. Three bits {S.sub.5,S.sub.3,S.sub.7} are read in the ascending order of indexes from a position with a position index  $P_0=N-M=5$  in the circular buffer. 4. The three data bits {S.sub.5,S.sub.3,S.sub.7} are sequentially arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 36

(304) Step 1 and step 2 are the same as those in the example 33. 3. Three bits {S.sub.7,S.sub.3,S.sub.5} are read in the descending order of indexes from the ending position in the circular buffer. 4. The three data bits {S.sub.7,S.sub.3,S.sub.5} are reversely arranged and transmitted as the rate matching data bit sequence to be transmitted.

#### Example 37

(305) Step 1 is the same as that in the example 33. 2. The bit sequence in the circular buffer obtained in the example 33 is reversely arranged to obtain {S.sub.7,S.sub.3,S.sub.5,S.sub.1,S.sub.6,S.sub.2,S.sub.4,S.sub.0}.

(306) Step 3 and step 4 are the same as those in the example 33.



#### Example 38

(307) Step 1 and step 2 are the same as those in the example 37.

(308) Step 3 and step 4 are the same as those in the example 34.

#### Example 39

(309) Step 1 and step 2 are the same as those in the example 37.

(310) Step 3 and step 4 are the same as those in the example 35.

#### Example 40

(311) Step 1 and step 2 are the same as those in the example 37.

(312) Step 3 and step 4 are the same as those in the example 36.

#### Example 41

(313) 1. The Polar code is performed on an information bit sequence of length  $K=24$  using code rate  $R=1/4$ , and the length of the encoded bit sequence is  $N=128$ . 2. The mapping function for mapping the initial bit sequence is determined by  $p(n)$ . The mapping function may be any one of the mapping functions in the examples 1 to 40, or may also be another one-to-one mapping function. 3. If the code rate  $R$  is less than the predefined threshold,  $M=96$  bits are read in the ascending order of indexes from a position with a position index  $P_0=N-M=32$  in the circular buffer.

#### Example 42

(314) 1. The Polar code is performed on the information bit sequence of length  $K=24$  using code rate  $R=2/3$ , and the length of the encoded bit sequence is  $N=64$ . 2. The mapping function for mapping the initial bit sequence is determined by  $p(n)$ . The mapping function may be any one of the mapping functions in the examples 1 to 40, or may also be another one-to-one mapping function. 3. If the code rate  $R$  is greater than the predefined threshold,  $M=36$  bits are read in the ascending order of indexes from the starting position in the circular buffer.

#### Embodiment 4

(315) This embodiment provides a storage medium. For example, in this embodiment, the storage medium may be configured to store program codes for executing the method for processing the bit sequence according to the embodiment described above.

(316) For another example, in this embodiment, the storage medium may be located in any one of a group of computer terminals in a computer network, or located in any one of a group of mobile terminals.

(317) For another example, in this embodiment, the storage medium is configured to store program codes for executing the steps described below.

(318) In S1,  $K$  bit channels used as information bits and  $(N-K)$  frozen bits are concatenated to generate a bit sequence of  $N$  bits, and the bit sequence of  $N$  bits is encoded by means of a Polar code encoder with a generator matrix of size  $N \times N$  to generate an initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  of  $N$  bits, where  $K$  and  $N$  are both positive integers and  $K$  is less than or equal to  $N$ .

(319) In S2, a circular buffer is divided into  $q$  parts, bits are selected from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in a non-repeated manner, and the bits are written into each part of the circular buffer according to a predefined rule, where  $q=1, 2, 3$  or  $4$ .

(320) In S3, a bit sequence of a specified length is sequentially selected from a predefined starting position in a bit sequence in the circular buffer and the bit sequence of the specified length is taken as a bit sequence to be transmitted.

(321) The serial numbers of the above embodiments are merely for ease of description and do not indicate superiority and inferiority of the embodiments.

(322) In the above embodiments, for a part not described in detail in one or more embodiments, reference may be made to the related description in other embodiments.

(323) The technical content disclosed in the embodiments of the present application may be implemented in other ways. The device embodiments described above are merely illustrative. For example, a unit classification is merely a logical function classification, and, in practice, the unit classification may be implemented in other ways. For example, multiple units or components may be combined or may be integrated into another system, or some features may be omitted or not executed. Additionally, the presented or discussed mutual coupling, direct coupling or communication connections may be indirect coupling or communication connections via interfaces, units or modules, or may be electrical or in other forms.

(324) The units described above as separate components may or may not be physically separated. Components presented as units may or may not be physical units, i.e., may be located in one place or may be distributed on multiple network units. Part or all of these units may be selected according to actual requirements to achieve objects of the solutions in the embodiments of the present disclosure.

(325) Additionally, multiple functional units in each embodiment may be integrated into one processing unit, or each unit may be physically present, or two or more units may be integrated into one unit. The integrated unit may be implemented by hardware or a software functional unit.

(326) The integrated unit may be stored in a computer-readable storage medium if implemented in the form of a software functional unit and sold or used as an independent product. The content provided by the present disclosure substantially or the part contributing to the existing art or all or part of the technical solutions may be embodied in the form of a software product. The software product is stored in a storage medium and includes several instructions for enabling a computer device (which may be a personal computer, a server, a network device or the like) to execute all or part of the

steps in the method according to the embodiments described above. The foregoing storage medium includes: a U disk, a read-only memory (ROM), a random access memory (RAM), a mobile hard disk, a magnetic disk, an optical disk or another medium capable of storing program codes.

## INDUSTRIAL APPLICABILITY

(327) The rate matching method and device for the Polar code provided by the present disclosure can solve the problems that Polar code hardware has high complexity and has a complicated encoding process in a hybrid automatic repeat request mechanism, significantly reducing the complexity of Polar code hardware and simplifying the encoding process.

## Claims

1. A rate matching method for a Polar code, comprising: generating a bit sequence of  $N$  bits from  $K$  information bits and  $(N-K)$  frozen bits, and encoding the bit sequence of  $N$  bits by means of a Polar code encoder with a generator matrix of size  $N \times N$  to generate an initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  of  $N$  bits, wherein  $K$  and  $N$  are both positive integers and  $K$  is less than or equal to  $N$ ; selecting bits from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in a non-repeated manner and writing the bits into a circular buffer; and generating a bit sequence of a specified length for transmission from the bits in the circular buffer based on a predefined starting position in the circular buffer, wherein the writing the bits into the circular buffer comprises writing the bits into the circular buffer based on a predefined rule, wherein the predefined rule is determined by a one-to-one mapping interleaving function  $f(n)$  generated according to a data characteristic of the Polar code, wherein  $n=0, 1, \dots, N-1$ ,  $f(n)=0, 1, \dots, N-1$ ,  $n$  is a bit position index in the initial bit sequence, and  $f(n)$  is a position index in the circular buffer, and wherein, in response to a code rate that is less than or equal to a predefined threshold, a position of  $P_{\text{sub}.0}=N-M$  in the circular buffer is taken as the predefined starting position, wherein  $P_{\text{sub}.0}$  represents a position index of the bit sequence in the circular buffer,  $M$  is a length of the bit sequence to be transmitted, and  $N$  is a length of the initial bit sequence.
2. The method of claim 1, wherein the generating the bit sequence of the specified length for transmission from the bits in the circular buffer based on the predefined starting position in the circular buffer comprises: sequentially selecting bits in an ascending order of indexes from a predefined position in the bit sequence in the circular buffer, reading from the predefined position to a first end of the bit sequence in the circular buffer, and continuing the reading from a second end of the bit sequence in the circular buffer until the bit sequence of the specified length is read.
3. An apparatus for rate matching for a Polar code, comprising: a processor; and a non-transitory memory with instructions thereon, wherein the instructions upon execution by the processor cause the processor to: generate a bit sequence of  $N$  bits from  $K$  information bits and  $(N-K)$  frozen bits, and encode the bit sequence of  $N$  bits by means of a Polar code encoder with a generator matrix of size  $N \times N$  to generate an initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  of  $N$  bits, wherein  $K$  and  $N$  are both positive integers and  $K$  is less than or equal to  $N$ ; select bits from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in a non-repeated manner and write the bits into a circular buffer; and generate a bit sequence of a specified length for transmission from the bits in the circular buffer based on a predefined starting position in the circular buffer, wherein the writing the bits into the circular buffer comprises writing the bits into the circular buffer based on a predefined rule, wherein the predefined rule is determined by a one-to-one mapping interleaving function  $f(n)$  generated according to a data characteristic of the Polar code, wherein  $n=0, 1, \dots, N-1$ ,  $f(n)=0, 1, \dots, N-1$ ,  $n$  is a bit position index in the initial bit sequence, and  $f(n)$  is a position index in the circular buffer, and wherein, in response to a code rate that is less than or equal to a predefined threshold, a position of  $P_{\text{sub}.0}=N-M$  in the circular buffer is taken as the predefined starting position, wherein  $P_{\text{sub}.0}$  represents a position index of the bit sequence in the circular buffer,  $M$  is a length of the bit sequence to be transmitted, and  $N$  is a length of the initial bit sequence.
4. The apparatus of claim 3, wherein the instructions upon execution by the processor further cause the processor, as part of generating the bit sequence of the specified length for transmission from the bits in the circular buffer based on the predefined starting position in the circular buffer, to: sequentially select bits in an ascending order of indexes from the predefined position in the bit sequence in the circular buffer, read from the predefined position to a first end of the bit sequence in the circular buffer, and continue to read from a second end of the bit sequence in the circular buffer until the bit sequence of the specified length is read.
5. A computer-readable storage medium comprising instructions which, when executed by a computing system, cause the computing system to carry out a method, comprising: generating a bit sequence of  $N$  bits from  $K$  information bits and  $(N-K)$  frozen bits, and encoding the bit sequence of  $N$  bits by means of a Polar code encoder with a generator matrix of size  $N \times N$  to generate an initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  of  $N$  bits, wherein  $K$  and  $N$  are both positive integers and  $K$  is less than or equal to  $N$ ; selecting bits from the initial bit sequence  $\{S_{\text{sub}.0}, S_{\text{sub}.1}, \dots, S_{\text{sub}.N-1}\}$  in a non-repeated manner and writing the bits into a circular buffer; and generating a bit sequence of a specified length for transmission from the bits in the circular buffer based on a predefined starting position in the circular buffer, wherein the writing the bits into the circular buffer comprises writing the bits into the circular buffer based on a predefined rule, wherein the predefined rule is determined by a one-to-one mapping interleaving function  $f(n)$  generated according to a data characteristic of the Polar code, wherein  $n=0, 1, \dots, N-1$ ,  $f(n)=0, 1, \dots, N-1$ ,  $n$  is a bit position index in the initial bit sequence, and  $f(n)$  is a position index in the circular buffer, and wherein, in response to a code rate

that is less than or equal to a predefined threshold, a position of  $P_{\text{sub}.0} = N - M$  in the circular buffer is taken as the predefined starting position, wherein  $P_{\text{sub}.0}$  represents a position index of the bit sequence in the circular buffer,  $M$  is a length of the bit sequence to be transmitted, and  $N$  is a length of the initial bit sequence.

6. The computer-readable storage medium of claim 5, wherein the generating the bit sequence of the specified length for transmission from the bits in the circular buffer based on the predefined starting position in the circular buffer comprises: sequentially selecting bits in an ascending order of indexes from a predefined position in the bit sequence in the circular buffer, reading from the predefined position to a first end of the bit sequence in the circular buffer, and continuing the reading from a second end of the bit sequence in the circular buffer until the bit sequence of the specified length is read.

---