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- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
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(54) Title: RATE MATCHING METHODS FOR LDPC CODES

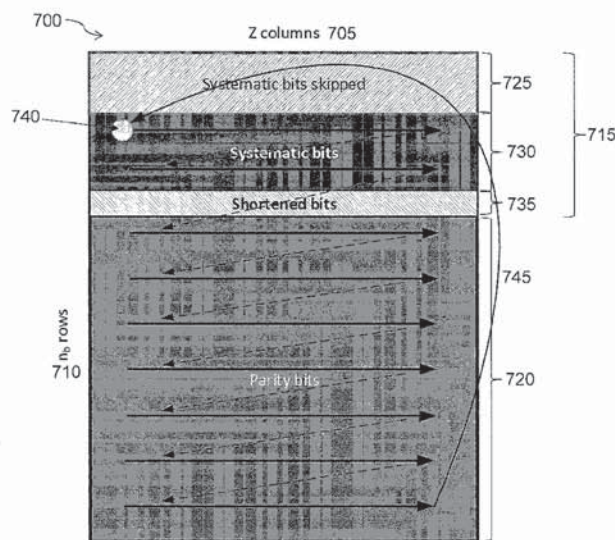


FIGURE 7

(57) Abstract: A method of producing a set of coded bits from a set of information bits for transmission between a first node (110, 115) and a second node (110, 115) in a wireless communications system (100), the method comprises generating (904) a codeword vector by encoding the set of information bits with a low-density parity-check code, wherein the codeword vector is composed of systematic bits and parity bits. The method comprises performing (908) circular buffer-based rate matching on the generated codeword vector to produce the coded bits for transmission, wherein the circular buffer-based rate matching comprises puncturing a first plurality of systematic bits.

MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(PCT Rule 71.1)

To:

WALTERS, Chad C.
BAKER BOTTS L.L.P.
2001 Ross Avenue, Suite 600
Dallas TX 75201
ETATS-UNIS D'AMERIQUE

Date of mailing
(day/month/year)

20.11.2018

Applicant's or agent's file reference
0179971170

IMPORTANT NOTIFICATION

International application No.
PCT/IB2017/054889

International filing date (day/month/year)
10.08.2017

Priority date (day/month/year)
12.08.2016

Applicant
Telefonaktiebolaget LM Ericsson (publ)

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary report on patentability and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.
4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary report on patentability. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

The applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purposes of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purposes of deciding whether, in that State, the claimed inventions is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

Name and mailing address of the international
preliminary examining authority:



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PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 0179971170	FOR FURTHER ACTION See Form PCT/PEA/416	
International application No. PCT/IB2017/054889	International filing date (day/month/year) 10.08.2017	Priority date (day/month/year) 12.08.2016
International Patent Classification (IPC) or national classification and IPC INV. H03M13/11		
Applicant Telefonaktiebolaget LM Ericsson (publ)		
1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36. 2. This REPORT consists of a total of <u>9</u> sheets, including this cover sheet. 3. This report is also accompanied by ANNEXES, comprising: a. ☒ (sent to the applicant and to the International Bureau) a total of <u>16</u> sheets, as follows: ☒ sheets of the description, claims and/or drawings which have been amended and/or sheets containing rectifications authorized by this Authority, unless those sheets were superseded or cancelled, and any accompanying letters (see Rules 46.5, 66.8, 70.16, 91.2, and Section 607 of the Administrative Instructions). ☐ sheets containing rectifications, where the decision was made by this Authority not to take them into account because they were not authorized by or notified to this Authority at the time when this Authority began to draw up this report, and any accompanying letters (Rules 66.4bis, 70.2(e), 70.16 and 91.2). ☐ superseded sheets and any accompanying letters, where this Authority either considers that the superseding sheets contain an amendment that goes beyond the disclosure in the international application as filed, or the superseding sheets were not accompanied by a letter indicating the basis for the amendments in the application as filed, as indicated in item 4 of Box No. I and the Supplemental Box (see Rule 70.16(b)). b. ☐ (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing, in the form of an Annex C/ST.25 text file, as indicated in the Supplemental Box Relating to Sequence Listing (see paragraph 3ter of Annex C of the Administrative Instructions).		
4. This report contains indications relating to the following items: ☒ Box No. I Basis of the report ☒ Box No. II Priority ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability ☐ Box No. IV Lack of unity of invention ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement ☒ Box No. VI Certain documents cited ☐ Box No. VII Certain defects in the international application ☐ Box No. VIII Certain observations on the international application		
Date of submission of the demand 12.06.2018	Date of completion of this report 20.11.2018	
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Fax: +49 89 2399 - 4465	Authorized officer Luca, Mihai Bogdan Telephone No. +49 89 2399-5896 	

Box No. I Basis of the report

1. With regard to the **language**, this report is based on
- ☒ the international application in the language in which it was filed
 - ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of:
 - ☐ international search (under Rules 12.3(a) and 23.1(b))
 - ☐ publication of the international application (under Rule 12.4(a))
 - ☐ international preliminary examination (under Rules 55.2(a) and/or 55.3(a) and (b))
2. With regard to the **elements*** of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

Description, Pages

1-31 as originally filed

Claims, Numbers

1-51 filed with telefax on 24-09-2018

Drawings, Sheets

1/14-14/14 as originally filed

- ☐ a sequence listing - see Supplemental Box Relating to Sequence Listing.
3. ☒ The amendments have resulted in the cancellation of:
- ☐ the description, pages
 - ☒ the claims, Nos. 7-8,20,23,26,33-34,46,49,52
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since either they are considered to go beyond the disclosure as filed, or they were not accompanied by a letter indicating the basis for the amendments in the application as filed, as indicated in the Supplemental Box (Rules 70.2(c) and (c-bis)):
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
5. ☐ This report has been established:
- ☐ taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rules 66.1(d-bis) and 70.2(e)).
 - ☐ without taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91(Rules 66.4bis and 70.2(e)).

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6. ☒ With regard to top-up searches (Rules 66.1 *ter* and 70.2(f)):
- ☒ A top-up search was carried out by this Authority on 10.07.2018 (all discovered documents are listed in the Supplemental Box Relating to Top-up Search).
 - ☐ Additional relevant documents have been discovered during the top-up search.
 - ☐ No top-up search was carried out by this Authority because it would serve no useful purpose.
7. ☐ Supplementary international search report(s) from Authority(ies) has/have been received and taken into account in establishing this report (Rule 45bis.8(b) and (c)).

* If item 4 applies, some or all of those sheets may be marked "superseded".

Box No. II Priority

1. ☐ This report has been established as if no priority had been claimed due to the failure to furnish within the prescribed time limit the requested:
- ☐ copy of the earlier application whose priority has been claimed (Rule 66.7(a)).
 - ☐ translation of the earlier application whose priority has been claimed (Rule 66.7(b)).
2. ☒ This report has been established as if no priority had been claimed due to the fact that the priority claim has been found invalid (Rule 64.1). Thus for the purposes of this report, the international filing date indicated above is considered to be the relevant date.
3. Additional observations, if necessary:
- see separate sheet

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>1-6, 9-19, 21, 22, 24, 25, 27-32, 35-45, 47, 48, 50, 51</u>
	No: Claims	
Inventive step (IS)	Yes: Claims	
	No: Claims	<u>1-6, 9-19, 21, 22, 24, 25, 27-32, 35-45, 47, 48, 50, 51</u>
Industrial applicability (IA)	Yes: Claims	<u>1-6, 9-19, 21, 22, 24, 25, 27-32, 35-45, 47, 48, 50, 51</u>
	No: Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

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Box No. VI Certain documents cited

1. Certain published documents (Rule 70.10)

and / or

2. Non-written disclosures (Rule 70.9)

see separate sheet

1 **Re Item II**

Priority

- 1.1 The priority document does not seem to include any claims. Therefore the claims as filed are a generalization of the subject-matter disclosed in the priority document. There are currently significant doubts that this generalization is directly and unambiguously derivable from the priority document and therefore the priority claim seems invalid. For example the priority document seems to refer specifically only to QC-LDPC whereas the claim specifies just LDPC; also the encoding on page 26 of the priority document seems to be very precise whereas claim 1 just mentions generating a codeword etc.
- 1.2 Document D5 cited below is an intermediate document and included as part of the priority document. Since the priority claim seems invalid, D5 seems to be part of prior art.

2 **Re Item V**

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following documents:

- D1 US 2008/320353 A1 (BLANKENSHIP YUFEI W [US] ET AL) 25 December 2008 (2008-12-25)
- D2 JUNG-FU CHENG ET AL: "Analysis of Circular Buffer Rate Matching for LTE Turbo Code",
2003 IEEE 58TH VEHICULAR TECHNOLOGY CONFERENCE. VTC
2003-FALL (IEEE CAT. NO.03CH37484), 1 January 2008 (2008-01-01),
pages 1-5, XP055152149,
ISSN: 1090-3038, DOI: 10.1109/VETECF.2008.162
ISBN: 978-0-78-037954-1
- D3 "5G; Study on New Radio (NR) access technology (3GPP TR 38.912 version 14.0.0 Release 14)",
ETSI TECHNICAL REPORT, EUROPEAN TELECOMMUNICATIONS
STANDARDS INSTITUTE (ETSI), 650, ROUTE DES LUCIOLES ;
F-06921 SOPHIA-ANTIPOLIS ; FRANCE,
vol. 3GPP RAN, no. V14.0.0 5 May 2017 (2017-05-05), pages 1-77,

XP014291080,
Retrieved from the Internet:
URL:[http://www.etsi.org/deliver/etsi_tr/
138900_138999/138912/14.00.00_60/tr_138912v140000p.pdf](http://www.etsi.org/deliver/etsi_tr/138900_138999/138912/14.00.00_60/tr_138912v140000p.pdf)
[retrieved on 2017-05-05]

- D4 MOSTAFA EL-KHAMY ET AL: "HARQ Rate-Compatible Polar Codes for Wireless Channels",
2015 IEEE GLOBAL COMMUNICATIONS CONFERENCE (GLOBECOM), 1 January 2014 (2014-01-01), pages 1-6, XP055397700,
DOI: 10.1109/GLOCOM.2014.7417429
- D5 ERICSSON: "LDPC Code Design for NR",
3GPP DRAFT; R1-166929 LDPC_CODE_DESIGN_FOR_NR, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE,
vol. RAN WG1, no. Gothenburg, Sweden; 20160822 - 20160826 13 August 2016 (2016-08-13), XP051142505,
Retrieved from the Internet:
URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_86/Docs/
[retrieved on 2016-08-13]

3 Article 33(3) PCT

The present application does not meet the criteria of Article 33(3) PCT, because the subject matter of claims 1-6, 9-19, 21, 22, 24, 25, 27-32, 35-45, 47, 48, 50, 51 is not inventive.

- 3.1 **Claim 1:** D1 discloses a method of producing a set of coded bits from a set of information bits for transmission between a first node and a second node in a wireless communications system (*figures 1, 3; par. [0001], [0004]*), the method comprising:
- generating a codeword vector by encoding the set of information bits with a low-density parity-check code (*par. [0005]: although D1 focuses on turbo codes, it specifies that the same concepts can be applied for LDPC*), wherein the codeword vector is composed of systematic bits and parity bits (*par. [0025]*); and
 - performing circular buffer-based rate matching on the generated codeword

vector to produce the coded bits for transmission (*par. [0027], [0028]*), wherein the circular buffer-based rate matching comprises puncturing a first plurality of systematic bits and writing a second plurality of systematic bits and the parity bits into a circular buffer (*par. [0078]-[0082]: systematic bits puncturing*).

The distinguishing feature is therefore:

- wherein puncturing the first plurality of systematic bits comprises omitting to write the first plurality of systematic bits into the a-circular buffer.

There is no particular technical effect in the application as filed associated with this feature except than the general rate-matching problem common to the whole application and citations. Thus it appears that the choice of omitting to write the first plurality of systematic bits is a design choice.

Furthermore, throughout the application, omitting to write or skipping when reading a first plurality of systematic bits from the circular buffer, are regarded as alternatives (see page 4, lines 13-15; page 7, lines 22-25; page 18, lines 10-13 etc.).

Even if some technical effect could be identified in particular to this feature, D1 discloses skipping a part of the systematic bits when reading from the circular buffer. Therefore, the skilled person would find obvious to replace this alternative with the one of actually omitting writing those bits in the buffer. As it was shown above, the description of the current application also seems to consider these features as alternatives.

The same reasoning applies when starting from D2 as closest prior art.

Thus, the solution proposed in claim 1 of the current application cannot be considered as inventive (Art. 33(3) PCT).

- 3.2 The subject-matter of independent **claim 27** corresponds in terms of apparatus features to that of claim 1. The objection raised in respect of this latter claim, therefore, also applies to independent claim 27 which is thus not allowable under Article 33(1) PCT for lack of inventive step of its subject-matter (Article 33(3) PCT).
- 3.3 The supplementary features specified by dependent claims 2-5, 10-18, 21, 24-25, 28-31, 36-44, 47, 50-51 are also anticipated by D1:
- **Claims 2, 28:** LDPC codes are defined by parity check matrices;
 - **Claims 3, 29:** *par. [0109]*;

- **Claims 4, 5, 30, 31:** par. [0071] - [0077];
- **Claims 10, 11, 36, 37:** implicit definition of a circular buffer;
- **Claims 12-17, 24, 38-43, 50:** par. [0057] - [0061], [0071] - [0077];
- **Claims 18, 44:** par. [0076]: scheme 2;
- **Claims 21, 47:** par. [0036] - [0043];
- **Claims 25, 51:** figures 4, 5;

Document D2 also discloses the subject-matter of claim 2-5, 10-18, 21, 24-25, 28-31, 36-44, 47, 50-51 (see citations in the Search Report).

Therefore, the subject matter of claim 2-5, 10-18, 21, 24-25, 28-31, 36-44, 47, 50-51 is not new (Article 33(3) PCT).

- 3.4 **Claims 6, 9, 32, 35:** The skilled person would find obvious employing a QC-LDPC code as a variant of the LDPC code mentioned in D1 or D2.

As a consequence, the subject matter of claims 6, 9, 32, 35 is not inventive (Article 33(3) PCT).

- 3.5 **Claims 19, 22, 45, 48:** well known puncturing solutions independent of the circular buffer configuration.

As a consequence, the subject matter of claims 19, 22, 45, 48 is not inventive (Article 33(3) PCT).

4 Re Item VI

Certain documents cited

Reference is made to the following documents:

- D3 "5G; Study on New Radio (NR) access technology (3GPP TR 38.912 version 14.0.0 Release 14)",
ETSI TECHNICAL REPORT, EUROPEAN TELECOMMUNICATIONS
STANDARDS INSTITUTE (ETSI), 650, ROUTE DES LUCIOLES ;
F-06921 SOPHIA-ANTIPOLIS ; FRANCE,
vol. 3GPP RAN, no. V14.0.0 5 May 2017 (2017-05-05), pages 1-77,
XP014291080,
Retrieved from the Internet:

URL:http://www.etsi.org/deliver/etsi_tr/138900_138999/138912/14.00.00_60/tr_138912v140000p.pdf
[retrieved on 2017-05-05]

- D5 ERICSSON: "LDPC Code Design for NR",
3GPP DRAFT; R1-166929 LDPC_CODE_DESIGN_FOR_NR, 3RD
GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE
COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921
SOPHIA-ANTIPOLIS CEDEX ; FRANCE,
vol. RAN WG1, no. Gothenburg, Sweden; 20160822 - 20160826 13
August 2016 (2016-08-13), XP051142505,
Retrieved from the Internet:
URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_86/Docs/
[retrieved on 2016-08-13]

Documents D3, D5 are intermediate documents and are relevant upon entry
in the regional phase.

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**IN THE INTERNATIONAL PRELIMINARY
EXAMINING AUTHORITY (IPEA/EP)**

In Re International Application No.:	PCT/IB2017/054889
International Filing Date:	10 August 2017
Applicant:	TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)
Docket No.:	017997.1170

SECOND AMENDMENT UNDER ARTICLE 34

The International Preliminary Examination Authority
European Patent Office
P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
NETHERLANDS

Attention: Mihai Bogdan Luca
Authorized Officer

Dear Sirs:

This communication is in response to the Written Opinion dated July 23, 2018, for the International Patent Application identified above.

REMARKS

In the Written Opinion mailed July 23, 2018 (hereinafter "Written Opinion"), the International Preliminary Examiner Authority (hereinafter "IPEA") opined that claims 1-6, 9-19, 21, 22, 24, 25, 27-32, 35-45, 47, 48, 50, and 51 lack novelty or an inventive step over D1 (US 2008/320353) in view of D2 (Cheng et al). The IPEA also asserted that the priority claim is invalid. Applicants will address the purported invalidity of the priority claim in the national/regional phase of prosecution. For the reasons discussed below, Applicant respectfully disagrees with the Written Opinion as to lack of novelty or inventive step.

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Claims are Novel and Inventive over D1 and D2

Claim 1 is novel and inventive over D1 and D2. Claim 1, as amended, recites:

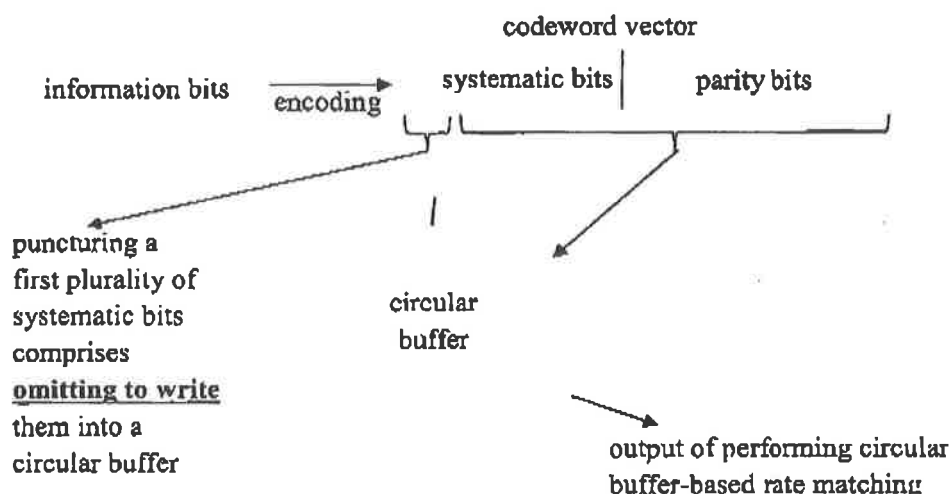
1. A method of producing a set of coded bits from a set of information bits for transmission between a first node (110, 115) and a second node (110, 115) in a wireless communications system (100), the method comprising:

generating (904) a codeword vector by encoding the set of information bits with a low-density parity-check code, wherein the codeword vector is composed of systematic bits and parity bits; and

performing (908) circular buffer-based rate matching on the generated codeword vector to produce the coded bits for transmission, wherein the circular buffer-based rate matching comprises puncturing a first plurality of systematic bits and writing a second plurality of systematic bits and the parity bits into a circular buffer,

wherein puncturing the first plurality of systematic bits comprises omitting to write the first plurality of systematic bits into the circular buffer.

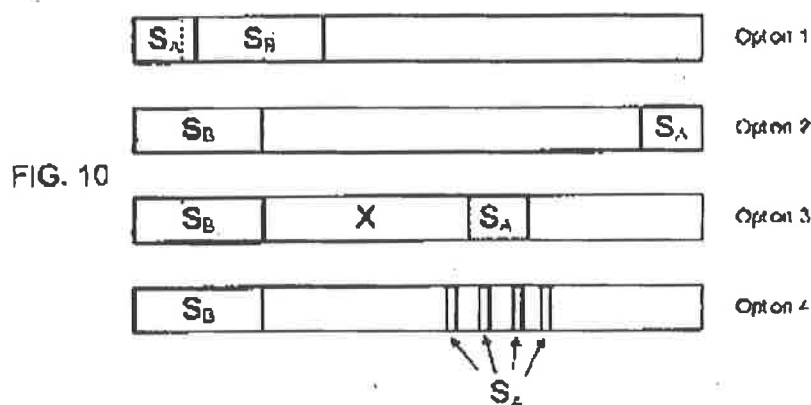
Claim 1 recites, in pertinent part, that a first plurality of systematic bits are punctured when performing circular buffer-based rate matching by omitting to write the first plurality of systematic bits into the circular buffer. The block diagram below depicts a simplified example of the claimed method. None of the cited references disclose omitting to write systematic bits into a circular buffer, as claimed.



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D1 discloses a method of assigning redundancy versions to a circular buffer. D1 further describes various forms of systematic bit puncturing in connection with the circular buffer to enhance performance. However, in all options described, all of the systematic bits are written into the circular buffer, i.e., no systematic bits are omitted from being written into the circular buffer. See D1 at ¶¶ 82-91. The puncturing in D1 occurs as bits are read from the buffer (e.g., in a first transmission the systematic bits S_A are not read from the buffer). The various puncturing options described by D1 are depicted in Figure 10 (copied below), where the shaded areas labeled " S_A " represent the systematic bits.



D2 similarly discloses circular buffer rate matching algorithms in which systematic bits are punctured. However, like D1, all systematic bits are written into the circular buffer. The puncturing occurs by starting a redundancy version at an offset compared to the beginning of the circular buffer. See D2 at page 2, col. 2, lines 5-13.

The foregoing arguments were presented in the previous response. However, in the Written Opinion the Examiner responded by noting that D1 teaches use of a virtual buffer and therefore "there is no active operation of writing...to the buffer." Thus, the Examiner concludes that D1 teaches omitting to write a first plurality of systematic bits into a circular buffer because, according to the Examiner's interpretation of D1, all of the codeword vector bits are omitted from being written into D1's virtual buffer.

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Applicant does not necessarily agree with the Examiner's characterization of the claim term "puncturing" as encompassing an omission of all codeword vector bits from being written to a buffer. However, to avoid any ambiguity Applicant has amended claim 1 to explicitly require the writing of some portion of the codeword vector bits into the circular buffer, as follows: "wherein the circular buffer-based rate matching comprises puncturing a first plurality of systematic bits and writing a second plurality of systematic bits and the parity bits into a circular buffer."

Thus, D1 and D2 fail, singly or in any combination, to disclose, teach, or suggest all of the features of claim 1, as amended. Accordingly, it is respectfully submitted that claim 1 is novel over D1 and D2.

Claim 1 is also inventive over D1 and D2. According to the EPO Guidelines for Examination, Part G, Chapter VII, Section 5.3:

...the question to be answered is whether there is any teaching in the prior art as a whole that would (not simply could, but would) have prompted the skilled person, faced with the objective technical problem, to modify or adapt the closest prior art while taking account of that teaching, thereby arriving at something falling within the terms of the claims, and thus achieving what the invention achieves (see G-VII, 4).

In other words, the point is not whether the skilled person could have arrived at the invention by adapting or modifying the closest prior art, but whether he would have done so because the prior art incited him to do so in the hope of solving the objective technical problem or in expectation of some improvement or advantage (see T 2/83). Even an implicit prompting or implicitly recognisable incentive is sufficient to show that the skilled person would have combined the elements from the prior art (see T 257/98 and T 35/04)...

Applicant respectfully submits that the cited prior art would not have incited a person of ordinary skill in the art to solve the technical problem suffered by conventional rate matching systems – namely, the lack of a simple and effective rate matching solution for use with LDPC data encoding – because D1 discloses rate matching techniques in which all systematic bits are written to a circular buffer and are therefore available for transmission depending on selected coding rate and/or the starting position of a redundancy version within the circular buffer. See D1 at Fig. 10 and ¶¶ 82-91. D2 and D3 suffer from similar deficiencies. Thus, while the solutions in D1, D2, and D3 may be appropriate for use in certain contexts, e.g., where a greater

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number of puncturing options are needed, there is no suggestion in D1, D2, or D3 for a simple, effective rate matching technique in which a plurality of systematic bits are omitted from being written into the circular buffer, as in Applicant's solution.

Therefore, D1, D2, and D3 would not have incited a skilled person to arrive at the features recited in claim 1. Accordingly, it is respectfully submitted that claim 1 is inventive over D1, D2, and D3.

Claims 27, as amended herein, contains features similar to claim 1 and is allowable for at least the same reasons. Accordingly, it is respectfully submitted that claim 27 is novel and inventive for at least the same reasons as claim 1.

Claims 2-19, 21, 22, 24, 25, 28-45, 47, 48, 50, and 51 variously depend from claims 1 and 27 and are novel and inventive for at least the same reasons as claim 1 and 27.

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Conclusion

The invention, as defined in the claims, is novel and inventive, at least for the reasons stated above.

Respectfully submitted,
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Claims

What is claimed is:

1. A method of producing a set of coded bits from a set of information bits for transmission
5 between a first node (110, 115) and a second node (110, 115) in a wireless communications system (100), the method comprising:

generating (904) a codeword vector by encoding the set of information bits with a low-density parity-check code, wherein the codeword vector is composed of systematic bits and parity bits; and

- 10 performing (908) circular buffer-based rate matching on the generated codeword vector to produce the coded bits for transmission, wherein the circular buffer-based rate matching comprises puncturing a first plurality of systematic bits and writing a second plurality of systematic bits and the parity bits into a circular buffer,

- wherein puncturing the first plurality of systematic bits comprises omitting to write the
15 first plurality of systematic bits into the circular buffer.

2. The method of Claim 1, wherein the low-density parity-check code is specified through a parity check matrix.

20

3. The method of Claim 1, wherein the first plurality of systematic bits that are punctured precedes, in an information vector comprising the information bits, the second plurality of systematic bits that are not punctured.

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4. The method of Claim 1, wherein a plurality of redundancy versions are defined over the circular buffer such that coded bits for a retransmission are read from the circular buffer according to a corresponding redundancy version defined for the retransmission.

5. The method of Claim 4, further comprising performing circular buffer-based rate matching on the generated codeword vector to produce coded bits for the retransmission, wherein the circular buffer-based rate matching for the retransmission comprises puncturing the first plurality of systematic bits.

10 6. The method of Claim 5, wherein the first plurality of systematic bits punctured for the retransmission includes an even multiple of Z systematic bits, where Z is a lifting factor of the parity check matrix.

7-8. Cancelled

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9. The method of any of Claims 1-6, wherein the first plurality of punctured systematic bits includes an even multiple of Z systematic bits, where Z is a lifting factor of the parity check matrix.

20 10. The method of any of Claims 1-6 and 9, wherein performing circular buffer-based rate matching on the generated codeword vector comprises:

reading the systematic bits and the parity bits out of a circular buffer to produce the transmission vector for transmission over a wireless channel.

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11. The method of Claim 10, wherein reading the systematic bits and the parity bits out of the circular buffer to produce the transmission vector for transmission over the wireless channel comprises:

5 if a number of bits of the transmission vector is larger than the total number of bits in the circular buffer, repeating one or more bits in the circular buffer by wrapping around.

12. The method of any of Claims 1-6 and 9-11, wherein generating the codeword vector by encoding the set of information bits comprises:

10 attaching dummy bits to the set of information bits, the dummy bits comprising bits of known value, to produce an information vector; and
encoding the information vector.

13. The method of Claim 12, wherein the attached dummy bits comprise a second plurality of systematic bits that is separate from the punctured first plurality of systematic bits.

15

14. The method of Claim 12, comprising puncturing the attached dummy bits.

15. The method of Claim 14, wherein puncturing the attached dummy bits comprises omitting to write the attached dummy bits into the circular buffer.

20

16. The method of Claim 14, wherein puncturing the attached dummy bits comprises skipping the attached dummy bits when reading the coded bits from the circular buffer.

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17. The method of any of Claims 1-6 and 9-16, wherein a subset of the systematic bits are omitted from being written into the circular buffer.

18. The method of any of Claims 1-6 and 9-17, comprising:

5 puncturing a subset of the systematic bits written into the circular buffer in a first transmission over the wireless channel; and

including the subset of the systematic bits that were punctured in a retransmission over the wireless channel.

10 19. The method of any of Claims 1-6 and 9-18, comprising:

puncturing bits column-wise such that bits are punctured evenly from each of a plurality of rows and a weight distribution of the parity check matrix is maintained in the circular buffer.

20. Cancelled

15

21. The method of any of Claims 1-6 and 9-18, wherein the systematic bits and the parity bits are read out so that a channel interleaver is implemented as part of performing circular buffer-based rate matching on the generated codeword vector.

20 22. The method of any of Claims 1-6, 9-19, and 21, wherein the punctured bits have a higher column weight than non-punctured bits.

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23. **Cancelled**

24. The method of any of Claims 1-6, 9-19, 21, and 22, wherein a subset of the parity bits are omitted from being written into the circular buffer.

5

25. The method of any of Claims 1-6, 9-19, 21, 22, and 24, wherein performing circular buffer-based rate matching on the generated codeword vector comprises:

writing at least a portion of the systematic bits and the parity bits as defined by a parity check matrix into a rectangular circular buffer, the rectangular circular buffer comprising one or more rows and one or more columns.

10

26. **Cancelled**

27. A first node (110, 115) for producing a set of coded bits from a set of information bits for transmission to a second node (110, 115) in a wireless communications system (100), the first node comprising:

15

processing circuitry (1020, 1120), the processing circuitry configured to:

generate (904) a codeword vector by encoding the set of information bits with a low-density parity-check code, wherein the codeword vector is composed of systematic bits and parity bits; and

20

perform (908) circular buffer-based rate matching on the generated codeword vector to produce the coded bits for transmission, wherein the circular buffer-based rate matching comprises puncturing a first plurality of systematic bits and writing a second plurality of systematic bits and the parity bits into a circular buffer,

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wherein puncturing the first plurality of systematic bits comprises omitting to write the first plurality of systematic bits into the circular buffer.

28. The first node of Claim 27, wherein the low-density parity-check code is specified
5 through a parity check matrix.

29. The first node of Claim 27, wherein the first plurality of systematic bits that are punctured precedes, in an information vector comprising the information bits, the second plurality of systematic bits that are not punctured.

10

30. The first node of Claim 27, wherein a plurality of redundancy versions are defined over the circular buffer such that coded bits for a retransmission are read from the circular buffer according to a corresponding redundancy version defined for the retransmission.

15 31. The first node of Claim 30, wherein the processing circuitry is further configured to perform circular buffer-based rate matching on the generated codeword vector to produce coded bits for the retransmission, wherein the circular buffer-based rate matching for the retransmission comprises puncturing the first plurality of systematic bits.

20 32. The first node of Claim 31, wherein the first plurality of systematic bits punctured for the retransmission includes an even multiple of Z systematic bits, where Z is a lifting factor of the parity check matrix.

33-34. Cancelled

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35. The first node of any of Claims 27-32, wherein the first plurality of punctured systematic bits includes an even multiple of Z systematic bits, where Z is a lifting factor of the parity check matrix.

5

36. The first node of any of Claims 27-32 and 35, wherein the processing circuitry configured to perform circular buffer-based rate matching on the generated codeword vector comprises processing circuitry configured to:

10 read the systematic bits and the parity bits out of a circular buffer to produce the transmission vector for transmission over a wireless channel.

37. The first node of Claim 36, wherein the processing circuitry configured to read the systematic bits and the parity bits out of the circular buffer to produce the transmission vector for transmission over the wireless channel comprises processing circuitry configured to:

15 if a number of bits of the transmission vector is larger than the total number of bits in the circular buffer, repeat one or more bits in the circular buffer by wrapping around.

38. The first node of any of Claims 27-32 and 35-37, wherein the processing circuitry configured to generate the codeword vector by encoding the set of information bits comprises
20 processing circuitry configured to:

attach dummy bits to the set of information bits, the dummy bits comprising bits of known value, to produce an information vector; and

encode the information vector.

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39. The first node of Claim 38, wherein the attached dummy bits comprise a second plurality of systematic bits that is separate from the punctured first plurality of systematic bits.

5 40. The first node of Claim 38, wherein the processing circuitry is further configured to puncture the attached dummy bits.

41. The first node of Claim 40, wherein the processing circuitry configured to puncture the attached dummy bits comprises processing circuitry configured to omit writing the attached dummy bits into the circular buffer.

10

42. The first node of Claim 40, wherein the processing circuitry configured to puncture the attached dummy bits comprises processing circuitry configured to skip the attached dummy bits when reading the coded bits from the circular buffer.

15 43. The first node of any of Claims 27-32 and 35-42, wherein a subset of the systematic bits are omitted from being written into the circular buffer.

44. The first node of any of Claims 27-32 and 35-43, wherein the processing circuitry is further configured to:

20 puncture a subset of the systematic bits written into the circular buffer in a first transmission over the wireless channel; and

include the subset of the systematic bits that were punctured in a retransmission over the wireless channel.

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45. The first node of any of Claims 27-32 and 35-44, wherein the processing circuitry is further configured to:

5 puncture bits column-wise such that bits are punctured evenly from each of a plurality of rows and a weight distribution of the parity check matrix is maintained in the circular buffer.

46. **Cancelled**

10 47. The first node of any of Claims 27-32 and 35-44, wherein the processing circuitry is configured to read out the systematic bits and the parity bits so that a channel interleaver is implemented as part of performing circular buffer-based rate matching on the generated codeword vector.

15 48. The first node of any of Claims 27-32 and 35-45, and 47, wherein the punctured bits have a higher column weight than non-punctured bits.

49. **Cancelled**

20 50. The first node of any of Claims 27-32 and 35-45, 47, and 48, wherein a subset of the parity bits are omitted from being written into the circular buffer.

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51. The first node of any of Claims 27-32 and 35-45, 47, 48, and 50, wherein the processing circuitry configured to perform circular buffer-based rate matching on the generated codeword vector comprises processing circuitry configured to:

- write at least a portion of the systematic bits and the parity bits as defined by a parity check matrix into a rectangular circular buffer, the rectangular circular buffer comprising one or more rows and one or more columns.

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