UNITED STATES PATENT AND TRADEMARK OFFICE

11/974,381 | I-2-0526.2US:

DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES

Application #	Attorney Docket #	Patent #	Status	Filing or 371 (c) date
11/974,381	I-2-0526.2US	8,074,143 Issued - 12/06/2011	Patented Case - 11/16/2011	10/12/2007

Documents & transaction history

Documents

Mail room date	Doc code	Doc description	Pages	Quick download
11/16/2011	ISSUE.NTF	Issue Notification	1	
10/27/2011	IFEE	Issue Fee Payment (PTO-85B)	1	
10/27/2011	WFEE	Fee Worksheet (SB06)	2	
10/27/2011	N417	Electronic Filing System(EFS) Acknowledgment Receipt	2	
09/28/2011	NOA	Notice of Allowance and Fees Due (PTOL-85)	5	
09/28/2011	SRNT	Examiner's search strategy and results	4	
09/28/2011	IIFW	Issue Information including classification, examiner, name, claim, renumbering, etc.	1	
09/28/2011	SRFW	Search information including classification, databases and other search related notes	1	
09/28/2011	BIB	Bibliographic Data Sheet	1	
09/28/2011	FWCLM	Index of Claims	1	
09/12/2011	SRNT	Examiner's search strategy and results	1	

Mail room date	Doc code	Doc description	Pages	Quick download
07/14/2011	A.QU	Response after Ex Parte Quayle Action	1	
07/14/2011	CLM	Claims	3	
07/14/2011	SPEC	Specification	1	
07/14/2011	REM	Applicant Arguments/Remarks Made in an Amendment	2	
07/14/2011	WFEE	Fee Worksheet (SB06)	2	
07/14/2011	N417	Electronic Filing System(EFS) Acknowledgment Receipt	3	
07/14/2011	XT/	Extension of Time	1	
07/14/2011	WFEE	Fee Worksheet (SB06)	1	
04/14/2011	CTEQ	Ex Parte Quayle Action	4	
04/14/2011	892	List of references cited by examiner	1	
04/14/2011	SRNT	Examiner's search strategy and results	4	
04/14/2011	1449	List of References cited by applicant and considered by examiner	3	
04/14/2011	1449	List of References cited by applicant and considered by examiner	3	
04/14/2011	SRFW	Search information including classification, databases and other search related notes	1	
04/14/2011	1449	List of References cited by applicant and considered by examiner	3	
04/14/2011	1449	List of References cited by applicant and considered by examiner	4	
04/14/2011	1449	List of References cited by applicant and considered by examiner	4	
04/14/2011	1449	List of References cited by applicant and considered by examiner	4	
04/07/2011	SRNT	Examiner's search strategy and results	1	
12/13/2010	IDS	Information Disclosure Statement (IDS) Form (SB08)	4	
12/13/2010	NPL	Non Patent Literature	6	

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12/13/2010	N417	Electronic Filing System(EFS) Acknowledgment Receipt	2	
12/13/2010	TRAN.LET	Transmittal Letter	2	
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04/14/2010	TRAN.LET	Transmittal Letter	2	
12/15/2009	IDS	Information Disclosure Statement (IDS) Form (SB08)	4	
12/15/2009	N417	Electronic Filing System(EFS) Acknowledgment Receipt	2	
12/15/2009	NPL	Non Patent Literature	76	
12/15/2009	TRAN.LET	Transmittal Letter	2	
05/29/2009	TRAN.LET	Transmittal Letter	2	
05/29/2009	IDS	Information Disclosure Statement (IDS) Form (SB08)	3	
05/29/2009	NPL	Non Patent Literature	31	
05/29/2009	N417	Electronic Filing System(EFS) Acknowledgment Receipt	2	
02/17/2009	IDS	Information Disclosure Statement (IDS) Form (SB08)	3	
02/17/2009	FOR	Foreign Reference	24	
02/17/2009	TRAN.LET	Transmittal Letter	3	
01/16/2009	A.PE	Preliminary Amendment	1	
01/16/2009	CLM	Claims	2	
01/16/2009	REM	Applicant Arguments/Remarks Made in an Amendment	1	
01/16/2009	N417	Electronic Filing System(EFS) Acknowledgment Receipt	2	
02/21/2008	NTC.PUB	Notice of Publication	1	
01/22/2008	TRAN.LET	Transmittal Letter	3	
01/22/2008	IDS	Information Disclosure Statement (IDS) Form (SB08)	3	

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01/22/2008	NPL	Non Patent Literature	7	
01/22/2008	NPL	Non Patent Literature	4	
01/22/2008	NPL	Non Patent Literature	5	
01/22/2008	NPL	Non Patent Literature	55	
01/22/2008	NPL	Non Patent Literature	53	
01/22/2008	NPL	Non Patent Literature	43	
01/22/2008	NPL	Non Patent Literature	43	
01/22/2008	NPL	Non Patent Literature	41	
01/22/2008	NPL	Non Patent Literature	41	
01/22/2008	NPL	Non Patent Literature	64	
01/22/2008	NPL	Non Patent Literature	74	
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01/22/2008	NPL	Non Patent Literature	75	
01/22/2008	FOR	Foreign Reference	107	
01/22/2008	NPL	Non Patent Literature	39	
01/22/2008	NPL	Non Patent Literature	40	
01/22/2008	NPL	Non Patent Literature	50	
01/22/2008	NPL	Non Patent Literature	50	
01/22/2008	NPL	Non Patent Literature	66	
01/22/2008	NPL	Non Patent Literature	66	
01/22/2008	NPL	Non Patent Literature	66	
11/21/2007	APP.FILE.REC	Filing Receipt	3	
11/15/2007	CFILE	Request for Corrected Filing Receipt	5	
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11/08/2007	APP.FILE.REC	Filing Receipt	3	

Mail room date	Doc code	Doc description	Pages	Quick download
11/08/2007	NTC.PUB.DATE	Notice of New or Revised Publication Date	1	
10/12/2007	TRNA	Transmittal of New Application	2	
10/12/2007	SPEC	Specification	38	
10/12/2007	CLM	Claims	4	
10/12/2007	ABST	Abstract	1	
10/12/2007	DRW	Drawings-only black and white line drawings	12	
10/12/2007	OATH	Oath or Declaration filed	6	
10/12/2007	ADS	Application Data Sheet	2	
10/12/2007	WFEE	Fee Worksheet (SB06)	1	
10/12/2007	WFEE	Fee Worksheet (SB06)	1	
10/12/2007	136A	Authorization for Extension of Time all replies	2	
10/12/2007	WFEE	Fee Worksheet (SB06)	1	

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/974,381	12/06/2011	8074143	I-2-0526.2US	4314

24374 7590 11/16/2011

VOLPE AND KOENIG, P.C.
DEPT. ICC
UNITED PLAZA
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 1089 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Philip J. Pietraski, Huntington Station, NY;
Gregory S. Sternberg, Mt. Laurel, NJ;

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(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/974,381	10/12/2007	Philip J. Pietraski	I-2-0526.2US	4314

TITLE OF INVENTION: DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1510	$300	$0	$1810	12/28/2011

EXAMINER	ART UNIT	CLASS-SUBCLASS
ALPHONSE, FRITZ	2112	714-755000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
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☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 Volpe and Koenig, P.C.
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: InterDigital Technology Corporation
(B) RESIDENCE: (CITY and STATE OR COUNTRY): Wilmington, Delaware 19810

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☑ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
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5. **Change in Entity Status** (from status indicated above)
☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

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Authorized Signature /Christina R. Walsh/ Date October 27, 2011
Typed or printed name Christina R. Walsh Registration No. 61553

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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Electronic Patent Application Fee Transmittal

Application Number:	11974381
Filing Date:	12-Oct-2007
Title of Invention:	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES
First Named Inventor/Applicant Name:	Philip J. Pietraski
Filer:	Christina R. Walsh/(CRW) denise ballantyne
Attorney Docket Number:	I-2-0526.2US

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	1501	1	1740	1740
Publ. Fee- early, voluntary, or normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**2040**

Electronic Acknowledgement Receipt	
EFS ID:	11279702
Application Number:	11974381
International Application Number:	
Confirmation Number:	4314
Title of Invention:	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES
First Named Inventor/Applicant Name:	Philip J. Pietraski
Customer Number:	24374
Filer:	Christina R. Walsh/(CRW) denise ballantyne
Filer Authorized By:	Christina R. Walsh
Attorney Docket Number:	I-2-0526.2US
Receipt Date:	27-OCT-2011
Filing Date:	12-OCT-2007
Time Stamp:	14:20:00
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$2040
RAM confirmation Number	595
Deposit Account	090435
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	I_2_0526_2US_IssueFee.PDF	937112 cad07a440bc57aab129bffd44618112a199b2d48	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	32575 d69309c2bf6e8f7929f27fb12837da8e20096d79	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	969687		

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EXAMINER
ALPHONSE, FRITZ

ART UNIT	PAPER NUMBER
2112	

DATE MAILED: 09/28/2011

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/974,381	10/12/2007	Philip J. Pietraski	I-2-0526.2US	4314

TITLE OF INVENTION: DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
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(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/974,381	10/12/2007	Philip J. Pietraski	I-2-0526.2US	4314

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EXAMINER	ART UNIT	CLASS-SUBCLASS
ALPHONSE, FRITZ	2112	714-755000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
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❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/974,381	10/12/2007	Philip J. Pietraski	I-2-0526.2US	4314

24374 7590 09/28/2011

VOLPE AND KOENIG, P.C.
DEPT. ICC
UNITED PLAZA
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103

EXAMINER	
ALPHONSE, FRITZ	

ART UNIT	PAPER NUMBER
2112	

DATE MAILED: 09/28/2011

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 853 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 853 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No.	Applicant(s)	
	11/974,381	PIETRASKI ET AL.	
	Examiner	Art Unit	
	FRITZ ALPHONSE	2112	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the amendment filed on 07/14/2011*.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are *10-17 (renumbered 1-8)*.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

/Fritz Alphonse/
Primary Examiner, Art Unit 2112

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	0	(wireless near4 communication interleaver virtual buffer parity bit larger).clm.	USPAT	AND	OFF	2011/09/14 20:56
L2	51	("7293217" "20040187069" "20080046800" "6622281" "7089480" "7523383" "7814390" "7814391" "7827466" "20040125765" "20060251001" "20090175298" "20090177950" "20090235147" "6397367" "6665833" "6807238" "6829305" "6903665" "7016427" "7146552" "7165209" "7251285" "7280609" "7415263" "7458011" "7673213" "7676731" "7676732" "7743312" RE41498 "20010009569" "20020027956" "20030097629" "20030171121" "20040139378" "20040187070" "20040257992" "20050053168" "20050100103" "20050172201" "20050283710" "20060031737" "20060179401" "20060190801" "20060206781" "20070101232" "20080279303" "20090106618" "20100281327" "20020051501" "7643448" "20060176976" "6088387" "6028897" "6014411" "6044116" "6370669" "6697986" "6744744" "6816556" "6892342" "7016658" "7027782" "7072307" "7200792" "7210089" "7283509" "7421033" "7483389" "7496079" "7536624" "7620872" "7640486" "7782973" "7802164" "7925963" "7958425" "7987414" "20010010710" "20010034209" "20020015419" "20020166093" "20030007476" "20030021240" "20030031233" "20030076870" "20030120995" "20030135811" "20040146029" "20040184553" "20050100085" "20050172202" "20050204251" "20050216819" "20060150051" "20060239237" "20070089025" "20080256424" "20090103480").pn.	USPAT	OR	OFF	2011/09/14 21:01
L3	0	(wireless communication interleaver virtual buffer parity bit larger).clm.	USPAT	AND	OFF	2011/09/14 21:01
L4	0	(wireless communication interleaver virtual buffer parity bit larger)	USPAT	SAME	OFF	2011/09/14 21:01
L5	74	(wireless communication interleaver virtual buffer parity bit larger)	USPAT	AND	OFF	2011/09/14 21:01
L6	3	2 and 5	USPAT	AND	OFF	2011/09/14 21:01
L9	3873	714/790,752,786,800,701,762,702,755.ccls.	USPAT	AND	OFF	2011/09/14 21:04
S1	33086	rate near4 match$4	US-PGPUB;	OR	ON	2011/04/07

			USPAT; EPO; JPO; DERWENT; IBM_TDB			21:08
S2	1040	S1 and (rate and match$4).ti.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:09
S3	0	S2 and interleav$4 nea4 (bit and parity and stream)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:11
S4	36	S2 and interleav$4 same (bit and parity and stream)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:12
S5	17	S4 and buffer$4 same interleav$4 near4 bit	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:13
S6	0	S5 and rate-match$4 same virtual near4 buffer	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:13
S7	4	S5 and rate near4 match$4 same virtual near4 buffer	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:13
S8	634	(rate matching interleaving systematic bits interleaving parity bit stream interleaving second parity bit stream)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:36
S9	199	(buffering interleaved systematic bits interleaved parity bit stream interleaved second parity bit stream virtual buffer bits interleaved systematic bits parity bit)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:38
S10	157	S8 and S9	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:38
S11	5	(buffering portion interleaved systematic bits interleaved parity bit stream second parity bit stream larger virtual buffer rate-matching perform rate matching virtual buffer)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:41
S12	5	S10 and S11	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:41
S13	6906	(pietraski or sternberg)	US-PGPUB;	OR	ON	2011/04/07

			USPAT; EPO; JPO; DERWENT; IBM_TDB			21:54
S14	201	(pietraski adj philip or sternberg adj gregory)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:54
S15	228552	wireless same transmit$4 same receiv$4	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:56
S16	3139	S15 and interleaver same bit	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:56
S17	714	S16 and parity near4 bit	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:57
S18	47	S17 and third near3 interleav$4	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:57
S19	4	S17 and third near3 interleav$4 same buffer	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:57
S20	8	S18 and rate near4 matching	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:58
S21	5	S20 and third adj interleav$4	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 22:03
S22	0	S21 and virtual adj bit	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 22:04
S23	7	("20020159501" | "20030079170" | "5689439" | "6351832" | "6560748" | "6631491" | "7028230").PN. OR ("7200792").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2011/04/07 22:08
S24	4	S8 and S14	US-PGPUB; USPAT; USOCR	OR	ON	2011/04/07 22:11
S25	3	S24 and virtual adj buffer	US-PGPUB; USPAT; EPO; JPO; DERWENT;	OR	ON	2011/04/07 22:16

			IBM_TDB			
S26	0	S25 and first adj interleaver	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 22:17
S27	181	("7293217" "20040187069" "20080046800" "6622281" "7089480" "7523383" "7814390" "7814391" "7827466" "20040125765" "20060251001" "20090175298" "20090177950" "20090235147" "6807238" "6903665" "20040139378" "20070101232" "20050053168" "7643448" "20060176976" "6397367" "6665833" "6829305" "7016427" "7146552" "7165209" "7251285" "7280609" "7415263" "7458011" "7673213" "7676731" "7676732" "7743312" RE41498 "20010009569" "20020027956" "20030097629" "20030171121" "20040187070" "20040257992" "20050100103" "20050172201" "20050283710" "20060031737" "20060179401" "20060190801" "20060206781" "20080279303" "20090106618" "20100281327" "5944850" "6028897" "6014411" "6044116" "6944233" "6961894" "7437655" "20010016931" "20030108115" "20050105605" "20100251062" "20100287453" "7640486" "20050100085" "6480503" "7000173" "20030159100" "20020051501" "20080137652" "6202189" "7263088" "20040047321" "6088387" "6370669" "6571366" "6697986" "6744744" "6816556" "6892342" "6898743" "6993697" "7016658" "7027782" "7072307" "7142610" "7142611" "7200792" "7210089" "7237179" "7283509" "7421033" "7483389" "7496079" "7536624" "7620872" "7782973" "7802164" "20010010710").pn.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 22:23
S28	1	S9 and S27	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 22:24

9/ 14/ 2011 9:08:22 PM
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Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11974381	PIETRASKI ET AL.
	Examiner	**Art Unit**
	FRITZ ALPHONSE	2112

ORIGINAL		INTERNATIONAL CLASSIFICATION									
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED				
714	755	H	0	3	M	13 / 00 (2006.01.01)					

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
714	786	790			

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	10														
2	11														
3	12														
4	13														
5	14														
6	15														
7	16														
8	17														

NONE (Assistant Examiner) (Date)	**Total Claims Allowed:** 8	
/FRITZ ALPHONSE/ Primary Examiner.Art Unit 2112 9/14/2011 (Primary Examiner) (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 10

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11974381	PIETRASKI ET AL.
	Examiner	**Art Unit**
	FRITZ ALPHONSE	2112

SEARCHED			
Class	**Subclass**	**Date**	**Examiner**
714	790,752,786,800,701,762,702,755	9/14/2011	FA

SEARCH NOTES		
Search Notes	**Date**	**Examiner**
East Search	9/14/2011	FA
Plus Search (See East Search)	9/14/2011	FA

INTERFERENCE SEARCH			
Class	**Subclass**	**Date**	**Examiner**
	PGPUB and Word Search of Claims have been Conducted for Interference.	9/14/2011	FA

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BIB DATA SHEET

CONFIRMATION NO. 4314

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/974,381	10/12/2007	714	2112	I-2-0526.2US

APPLICANTS

Philip J. Pietraski, Huntington Station, NY;
Gregory S. Sternberg, Mt. Laurel, NJ;

**** CONTINUING DATA ***************************

This application is a CON of 10/725,779 12/02/2003 PAT 7,293,217
which claims benefit of 60/434,232 12/16/2002
and claims benefit of 60/444,068 01/30/2003
and claims benefit of 60/470,921 05/15/2003
and claims benefit of 60/494,404 08/11/2003

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

11/02/2007

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /FRITZ ALPHONSE/ Examiner's Signature	☐ Met after Allowance FA Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		NY	12	9	4

ADDRESS

VOLPE AND KOENIG, P.C.
DEPT. ICC
UNITED PLAZA
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103
UNITED STATES

TITLE

Detection, avoidance and/or correction of problematic puncturing patterns in parity bit streams used when implementing turbo codes

FILING FEE RECEIVED	FEES: Authority has been given in Paper	☐ All Fees
1240	No._____ to charge/credit DEPOSIT ACCOUNT	☐ 1.16 Fees (Filing)
	No._____ for following:	☐ 1.17 Fees (Processing Ext. of time)
		☐ 1.18 Fees (Issue)
		☐ Other _____
		☐ Credit

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11974381	PIETRASKI ET AL.
	Examiner	Art Unit
	FRITZ ALPHONSE	2112

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original									
1	10									
2	11									
3	12									
4	13									
5	14									
6	15									
7	16									
8	17									

PLUS Search Results for S/N 11974381, Searched Mon Sep 12 12:11:33 EDT 2011

The Patent Linguistics Utility System (PLUS) is a USPTO automated search system for U.S. Patents from 1971 to the present PLUS is a query-by-example search system which produces a list of patents that are most closely related linguistically to the application searched. This search was prepared by the staff of the Scientific and Technical Information Center, SIRA.

7293217 86
20040187069 86
20080046800 86
6622281 79
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20050172202 64
20050204251 64
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20090103480 64

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the **PATENT APPLICATION** of:	
	Pietraski et al.
Application No.:	11/974,381
Confirmation No.:	4314
Filed:	October 12, 2007
For:	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES
Group:	2112
Examiner:	Fritz Alphonse

Our File:	I-2-0526.2US
Date:	July 14, 2011

REPLY PURSUANT TO 37 C.F.R. §1.111

Mail Stop Amendment
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

Sir:

This Reply is being filed in response to the *Ex Parte Quayle* Office Action dated April 14, 2011 and is submitted in conjunction with an appropriate petition for extension of time.

Please amend the application without prejudice or disclaimer as follows:

Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims

Claims 1. – 9. (Canceled)

10. (Currently amended) A method of rate matching comprising:

interleaving systematic bits;

interleaving a first parity bit stream;

interleaving a second parity bit stream;

buffering the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream in a virtual buffer when the number of bits of the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream is not larger than the virtual buffer;

buffering a portion of the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream when the number of bits of the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream is larger than the virtual buffer; and

~~using a rate-matching unit to perform~~ performing rate matching on at least one output of the virtual buffer.

11. (Previously presented) The method of claim 10 wherein the buffered portion includes all of the interleaved systematic bits.

12. (Previously presented) The method of claim 10 further comprising:

collecting bits associated with the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream.

13. (Currently amended) ~~A wireless transmit/receive unit (WTRU)~~ An apparatus for use in wireless communications comprising:

a first interleaver configured to interleave systematic bits;

a second interleaver configured to interleave a first parity bit stream;

a third interleaver configured to interleave a second parity bit stream;

a virtual buffer configured to buffer the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream when the number of bits of the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream is not larger than the virtual buffer and configured to buffer a portion of the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream when the number of bits of the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream is larger than the virtual buffer; and

a rate matching unit configured to perform rate matching on at least one output of the virtual buffer.

14. (Currently amended) The ~~WTRU~~ apparatus of claim 13 wherein the buffered portion includes all of the interleaved systematic bits.

15. (Currently amended) The ~~WTRU~~ apparatus of claim 13 further comprising:

a bit collection unit configured to collect bits associated with the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream.

16. (New) The apparatus of claim 13 configured as a wireless transmit/receive unit (WTRU).

17. (New) The apparatus of claim 13 configured as a Node B.

Amendments to the Specification

Please replace paragraph [0003] with the following amended paragraph:

[0003] This application is a continuation of U.S. Patent Application Serial No. 10/725,779, filed on December 2, 2003, now U.S. Patent No. 7,293,217, issued November 6, 2007, which claims the benefit of U.S. Provisional Patent Applications Serial No. 60/434,232, filed on December 16, 2002, Serial No. 60/444,068, filed on January 30, 2003, Serial No. 60/470,921, filed on May 15, 2003, and Serial No. 60/494,404 filed on August 11, 2003, which are incorporated by reference as if fully set forth herein.

REMARKS/ARGUMENTS

After the foregoing amendment, claims 10–17 are currently pending in this application. Claims 10 and 13–15 are amended. New claims 16 and 17 are added. In the specification, paragraph [0003] is amended.

Allowable Subject Matter

Applicants thank the Examiner for indicating that claims 10–15 contain allowable subject matter.

Amendment to the Specification

The specification has been amended to include the issued patent in the parent case.

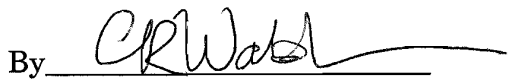
Conclusion

If the Examiner believes that any additional minor formal matters need to be addressed in order to place this application in condition for allowance, or that a telephonic interview will help to materially advance the prosecution of this application, the Examiner is invited to contact the undersigned by telephone at the Examiner's convenience.

In view of the foregoing amendment and remarks, Applicants respectfully submit that the present application is in condition for allowance and a notice to that effect is respectfully requested.

Respectfully submitted,

Pietraski et al.

By 
Christina R. Walsh
Registration No. 61,553

Volpe and Koenig, P.C.
United Plaza
30 South 17th Street
Philadelphia, PA 19103-4009
Telephone: (215) 568-6400
Facsimile: (215) 568-6499

CRW/dml
Enclosure

Electronic Patent Application Fee Transmittal

Application Number:	11974381
Filing Date:	12-Oct-2007
Title of Invention:	Detection, avoidance and/or correction of problematic puncturing patterns in parity bit streams used when implementing turbo codes
First Named Inventor/Applicant Name:	Philip J. Pietraski
Filer:	Steven J. Gelman/Dawn Larsen
Attorney Docket Number:	I-2-0526.2US

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 1 month with $0 paid	1251	1	130	130

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**130**

Electronic Acknowledgement Receipt	
EFS ID:	10524018
Application Number:	11974381
International Application Number:	
Confirmation Number:	4314
Title of Invention:	Detection, avoidance and/or correction of problematic puncturing patterns in parity bit streams used when implementing turbo codes
First Named Inventor/Applicant Name:	Philip J. Pietraski
Customer Number:	24374
Filer:	Steven J. Gelman/Dawn Larsen
Filer Authorized By:	Steven J. Gelman
Attorney Docket Number:	I-2-0526.2US
Receipt Date:	14-JUL-2011
Filing Date:	12-OCT-2007
Time Stamp:	17:42:22
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$130
RAM confirmation Number	4554
Deposit Account	090435
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees) Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Extension of Time	20110714_I_2_0526_2US_Extension_of_Time.PDF	46894 c97c8a0e41a0e30d7eae1d6a43733e23f939305c	no	1
Warnings:					
Information:					
2		20110714_I_2_0526_2US_Ex_Parte_Reply.PDF	137651 d7e9eccee9b8e8dc749b9bec6933beb308685d6b	yes	7

Multipart Description/PDF files in .zip description

Document Description	Start	End
Response after Ex Parte Quayle Action	1	1
Claims	2	4
Specification	5	5
Applicant Arguments/Remarks Made in an Amendment	6	7

Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	30276 9d4e22951627b3b568678d37ab82e3cc690658c6	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	214821		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/22 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARMENT OF COMMERCE
Under the paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a) **FY 2009** ***(Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).)***	Docket Number (Optional) I-2-0526.2US
Application Number 11/974,381	Filed October 12, 2007
For Detection, Avoidance and/or Correction of Problematic Puncturing Patterns in Parity Bit Streams...	
Art Unit 2112	Examiner Fritz Alphonse

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	Fee	Small Entity Fee	
☒ One month (37 CFR 1.17(a)(1))	$130	$65	$ 130
☐ Two months (37 CFR 1.17(a)(2))	$490	$245	$
☐ Three months (37 CFR 1.17(a)(3))	$1110	$555	$
☐ Four months (37 CFR 1.17(a)(4))	$1730	$865	$
☐ Five months (37 CFR 1.17(a)(5))	$2350	$1175	$

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☒ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 09-0435.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed (Form PTO/SB/96).

☒ attorney or agent of record. Registration Number 61,553

☐ attorney or agent under 37 CFR 1.34.
Registration number if acting under 37 CFR 1.34 _____

CRWalsh

Signature — July 14, 2011 (Date)

Christina R. Walsh (Typed or printed name) — 215-568-6400 (Telephone Number)

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below.

☐ Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.136(a). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
11/974,381	10/12/2007	

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)	SMALL ENTITY ☐		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

		(Column 1)		(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
	07/14/2011	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
AMENDMENT	Total (37 CFR 1.16(i))	* 8	Minus	** 20	= 0	X $ =		OR	X $52=	0
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $ =		OR	X $220=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)					
		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
AMENDMENT	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/MARCUS PRIDGEN/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/974,381	10/12/2007	Philip J. Pietraski	I-2-0526.2US	4314

24374 7590 04/14/2011
VOLPE AND KOENIG, P.C.
DEPT. ICC
UNITED PLAZA
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103

EXAMINER	
ALPHONSE, FRITZ	

ART UNIT	PAPER NUMBER
2112	

NOTIFICATION DATE	DELIVERY MODE
04/14/2011	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

eoffice@volpe-koenig.com

Office Action Summary	Application No.	Applicant(s)	
	11/974,381	PIETRASKI ET AL.	
	Examiner	Art Unit	
	FRITZ ALPHONSE	2112	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *2* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *12 October 2007*.

2a)☐ This action is **FINAL**. 2b)☐ This action is non-final.

3)☒ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *10-15* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☒ Claim(s) *10-15* is/are allowed.

6)☐ Claim(s) _____ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *12 October 2007* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *6*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Specification

1. The Specification of the disclosure (see Cross Reference to Related Applications, paragraph [0002-0003]) filed on 10/12/2007 should be updated because it includes U.S. Patent Application No. 10/725,779, which has been issued as patent. Correction is required. See MPEP § 608.01(b).

Allowable Subject Matter

2. After further search and thorough examination of the present application and in view of the prior art of record, claims 10-15 are found to be in condition for allowance.

Conclusion

3. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Fritz Alphonse, whose telephone number is (571) 272-3813. The examiner can normally be reached on M-F, 8:30-6:00, Alt. Mondays off.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Scott Baderman, can be reached at (571) 272-3644.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Group receptionist whose telephone number is (571) 272-3824

Information regarding the status of an application may also be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR

system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

/Fritz Alphonse/

Primary Examiner, Art Unit 2112

Notice of References Cited	Application/Control No. 11/974,381	Applicant(s)/Patent Under Reexamination PIETRASKI ET AL.	
	Examiner FRITZ ALPHONSE	Art Unit 2112	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-7,028,230	04-2006	Manninen et al.	714/702
*	B	US-6,631,491	10-2003	Shibutani et al.	714/762
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	33086	rate near4 match$4	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:08
S2	1040	S1 and (rate and match$4).ti.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:09
S3	0	S2 and interleav$4 nea4 (bit and parity and stream)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:11
S4	36	S2 and interleav$4 same (bit and parity and stream)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:12
S5	17	S4 and buffer$4 same interleav$4 near4 bit	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:13
S6	0	S5 and rate-match$4 same virtual near4 buffer	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:13
S7	4	S5 and rate near4 match$4 same virtual near4 buffer	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:13
S8	634	(rate matching interleaving systematic bits interleaving parity bit stream interleaving second parity bit stream)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:36
S9	199	(buffering interleaved systematic bits interleaved parity bit stream interleaved second parity bit stream virtual buffer bits interleaved systematic bits parity bit)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:38

EAST Search History (Prior Art)

S10	157	S8 and S9	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:38
S11	5	(buffering portion interleaved systematic bits interleaved parity bit stream second parity bit stream larger virtual buffer rate-matching perform rate matching virtual buffer)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:41
S12	5	S10 and S11	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	AND	ON	2011/04/07 21:41
S13	6906	(pietraski or sternberg)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:54
S14	201	(pietraski adj philip or sternberg adj gregory)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:54
S15	228552	wireless same transmit$4 same receiv$4	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:56
S16	3139	S15 and interleaver same bit	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:56
S17	714	S16 and parity near4 bit	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:57
S18	47	S17 and third near3 interleav$4	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:57
S19	4	S17 and third near3 interleav$4 same buffer	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:57

EAST Search History (Prior Art)

S20	8	S18 and rate near4 matching	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 21:58
S21	5	S20 and third adj interleav$4	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 22:03
S22	0	S21 and virtual adj bit	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 22:04
S23	7	("20020159501" | "20030079170" | "5689439" | "6351832" | "6560748" | "6631491" | "7028230").PN. OR ("7200792").URPN.	US-PGPUB; USPAT; USOCR	OR	ON	2011/04/07 22:08
S24	4	S8 and S14	US-PGPUB; USPAT; USOCR	OR	ON	2011/04/07 22:11
S25	3	S24 and virtual adj buffer	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 22:16
S26	0	S25 and first adj interleaver	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 22:17

EAST Search History (Prior Art)

S27	181	("7293217" "20040187069" "20080046800" "6622281" "7089480" "7523383" "7814390" "7814391" "7827466" "20040125765" "20060251001" "20090175298" "20090177950" "20090235147" "6807238" "6903665" "20040139378" "20070101232" "20050053168" "7643448" "20060176976" "6397367" "6665833" "6829305" "7016427" "7146552" "7165209" "7251285" "7280609" "7415263" "7458011" "7673213" "7676731" "7676732" "7743312" RE41498 "20010009569" "20020027956" "20030097629" "20030171121" "20040187070" "20040257992" "20050100103" "20050172201" "20050283710" "20060031737" "20060179401" "20060190801" "20060206781" "20080279303" "20090106618" "20100281327" "5944850" "6028897" "6014411" "6044116" "6944233" "6961894" "7437655" "20010016931" "20030108115" "20050105605" "20100251062" "20100287453" "7640486" "20050100085" "6480503" "7000173" "20030159100" "20020051501" "20080137652" "6202189" "7263088" "20040047321" "6088387" "6370669" "6571366" "6697986" "6744744" "6816556" "6892342" "6898743" "6993697" "7016658" "7027782" "7072307" "7142610" "7142611" "7200792" "7210089" "7237179" "7283509" "7421033" "7483389" "7496079" "7536624" "7620872" "7782973" "7802164" "20010010710").pn.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 22:23
S28	1	S9 and S27	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/04/07 22:24

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /F.A./

OIPE JAN 22 2008 PATENT & TRADEMARK OFFICE

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use several sheets if necessary)	ATTY. DOCKET NO. I-2-0526.2US	SERIAL NO. 11/974,381
	APPLICANT Pietraski et al.	
	FILING DATE October 12, 2007	GROUP 2112

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/F.A./		6,370,669	04/2002	Eroz et al.			
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		6,665,813	12/2003	Forsman et al.			
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		2002/0027956	03/2002	Lee et al.			
		2002/0141433	10/2002	Kwon et al.			
		2003/0007476	01/2003	Kim et al.			

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/F.A./		00/11791	03/2000	WO			X[1]	
		00/41343	07/2000	WO			X[2]	
		02/33910	04/2002	WO			X[3]	
		03/069784	08/2003	WO			X[4]	

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X[1] Equivalent to RU 2190296

X[2] Equivalent to RU 2185025

X[3] Equivalent to RU 2239292

X[4] Equivalent to RU 2004127246

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04/08/2011

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/F.A./	*	00/065446	06/2005	WO				
		00/011791	03/2000	WO			X[1]	
		00/041343	07/2000	WO			X[2]	
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The PTO did not receive the following listed item(s) only 1 Feb Wo/00/45446

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	11974381	PIETRASKI ET AL.
	Examiner	**Art Unit**
	FRITZ ALPHONSE	2112

SEARCHED			
Class	**Subclass**	**Date**	**Examiner**
714	790,752,786,800,701,762,702,755	4/8/11	FA

SEARCH NOTES		
Search Notes	**Date**	**Examiner**
East Search	4/8/11	FA
Plus Search (See East Search)	4/8/11	FA

INTERFERENCE SEARCH			
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X[1] Equivalent to RU 2190296

X[2] Equivalent to RU 2185025

X[3] Equivalent to RU 2239292

X[4] Equivalent to RU 2004127246

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FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use several sheets if necessary)	ATTY. DOCKET NO. I-2-0526.2US	SERIAL NO. 11/974,381
	APPLICANT Pietraski et al.	
	FILING DATE October 12, 2007	GROUP 2112

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/F.A./		6,370,669	04/2002	Eroz et al.			
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		6,622,281	09/2003	Yun et al.			
		6,665,813	12/2003	Forsman et al.			
		7,076,726	07/2006	Yun et al.			
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		2002/0141433	10/2002	Kwon et al.			
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X[2] Equivalent to RU 2185025

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X[3] Equivalent to RU 2239292

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1248907-1

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[1] Equivalent to RU 2190296 ;[2] Equivalent to RU 2185025; [3] Equivalent to RU 2239292; [4] Equivalent to RU 2004127246;

[5] Equivalent to TW 478258 and TW 454391.

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		Mo et al., "Analysis of Puncturing Pattern for High Rate Turbo Codes," IEEE International, 0-7803-5538-5/99, 1999, pgs. 547-550.
	*	NORTEL NETWORKS, "Proposal for Rate Matching for Turbo Codes," pp. 1-5 (May 12, 1999).
		SIEMENS ET AL., "HSDPA For The 1,28 Mcps TDD Option – A-VRC Test Methodology And Simulation Assumptions", TSG-RAN Working Group 4 (Radio) Meeting #26, R4-030223, (Madrid, Spain 17-21 February 2003).
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	FILING DATE October 12, 2007	GROUP 2112

EXAMINER INITIAL		DESCRIPTION (Including Author, Title, Date, Pertinent Pages, Etc.)
/F.A./		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) Protocol Specification (Release 1999)", 3GPP TS 25.321 V3.16.0 (September 2003).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; MAC Protocol Specification (Release 1999)", 3GPP TS 25.321 V3.13.0 (September 2002).
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EXAMINER	DATE CONSIDERED
/Fritz Alphonse/	04/08/2011

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1461597-1

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PLUS Search Results for S/N 11974381, Searched Thu Apr 07 10:35:11 EDT 2011

The Patent Linguistics Utility System (PLUS) is a USPTO automated search system for U.S. Patents from 1971 to the present PLUS is a query-by-example search system which produces a list of patents that are most closely related linguistically to the application searched. This search was prepared by the staff of the Scientific and Technical Information Center, SIRA.

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		6,266,795	07/2001	Wei			
		6,370,669	04/2002	Eroz et al.			
		6,397,367	05/2002	Park et al.[5]			
		6,601,214	07/2003	Hammons, Jr.			
		6,622,281	09/2003	Yun et al.			
		6,665,813	12/2003	Forsman et al.			
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		2002/0141433	10/2002	Kwon et al.			
		2003/0007476	01/2003	Kim et al.			

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		00/065446	06/2005	WO				
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		Mo et al., "Analysis of Puncturing Pattern for High Rate Turbo Codes," IEEE International, 0-7803-5538-5/99, 1999, pgs. 547-550.
	*	NORTEL NETWORKS, "Proposal for Rate Matching for Turbo Codes," pp. 1-5 (May 12, 1999).
		SIEMENS ET AL., "HSDPA For The 1,28 Mcps TDD Option – A-VRC Test Methodology And Simulation Assumptions", TSG-RAN Working Group 4 (Radio) Meeting #26, R4-030223, (Madrid, Spain 17-21 February 2003).
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1461597-1

Electronic Acknowledgement Receipt

EFS ID:	9024628
Application Number:	11974381
International Application Number:	
Confirmation Number:	4314
Title of Invention:	Detection, avoidance and/or correction of problematic puncturing patterns in parity bit streams used when implementing turbo codes
First Named Inventor/Applicant Name:	Philip J. Pietraski
Customer Number:	24374
Filer:	Robert Solomon/Carey Kulp
Filer Authorized By:	Robert Solomon
Attorney Docket Number:	I-2-0526.2US
Receipt Date:	13-DEC-2010
Filing Date:	12-OCT-2007
Time Stamp:	18:19:48
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	ids.pdf	52053 470f67763ecd9b40c60112ec8d517ff30479104e	no	2

Warnings:	
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2	Information Disclosure Statement (IDS) Filed (SB/08)	pto1449.pdf	58501 4c278379bbc183cd99738965cfdf3b95cf86f159	no	4
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3	NPL Documents	NORTEL.PDF	214477 b19822b55df8efc64130311205882b90be4703d8	no	6
Warnings:					
Information:					
			Total Files Size (in bytes):	325031	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the PATENT APPLICATION of:	
	Pietraski et al.
Application No.:	11/974,381
Confirmation No.:	4314
Filed:	October 12, 2007
For: DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	
Group:	2112
Examiner:	Jacques H. Louis Jacques

Our File:	I-2-0526.2US
Date:	December 13, 2010

INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment (via EFS)
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Further to Applicants' Duty of Disclosure pursuant to 37 C.F.R. §1.56, Applicants wish to bring to the Examiner's attention the material cited on the enclosed Form PTO-1449.

The listed references include references previously cited in this application. Newly cited documents are indicated by an asterisk (*) on the enclosed Form PTO-1449. Copies of the newly cited documents are enclosed.

This Application is a continuation of Non-Provisional Application No. 10/725,779, filed on December 2, 2003, which issued on November 6, 2007 as U.S. Patent No. 7,293,217, which claims priority from Provisional Application No. 60/494,404, which was filed on August 11, 2003, Provisional Application No. 60/434,232, which was filed on December 16, 2002, Provisional Application No. 60/444,068, which was filed on January 30, 2003, and Provisional Application No. 60/470,921, which was filed on May 15, 2003.

It is respectfully requested that the Examiner consider these documents and return an initialed copy of the Form PTO-1449 indicating consideration of the cited materials.

Respectfully submitted,

Pietraski et al.

By_/Christina R. Walsh/_____
Christina R. Walsh
Registration No. 61,553
(215) 568-6400

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United Plaza, Suite 1600
30 South 17th Street
Philadelphia, PA 19103

CRW/pck
Enclosures (2)

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		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (FDD) (Release 5)", 3GPP TS 25.212 V5.4.0 (March 2003).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (FDD) (Release 5)", 3GPP TS 25.212 V5.6.0 (September 2003).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.7.0 (September 2004).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 1999)", 3GPP TS 25.222 V3.8.0 (March 2002).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 1999)", 3GPP TS 25.222 V3.10.0 (September 2002).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 4)", 3GPP TS 25.222 V4.5.0 (September 2002).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 4)", 3GPP TS 25.222 V4.6.0 (December 2002).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.2.1 (October 2002).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.4.0 (March 2003).

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

1248907-1

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use several sheets if necessary)	ATTY. DOCKET NO. I-2-0526.2US	SERIAL NO. 11/974,381
	APPLICANT Pietraski et al.	
	FILING DATE October 12, 2007	GROUP 2112

EXAMINER INITIAL		DESCRIPTION (Including Author, Title, Date, Pertinent Pages, Etc.)
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.5.0 (June 2003).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; High Speed Downlink Packet Access: Physical Layer Aspects (Release 5)," 3GPP TR 25.858 V5.0.0 (March 2002).

[1] Equivalent to RU 2190296 ;[2] Equivalent to RU 2185025; [3] Equivalent to RU 2239292; [4] Equivalent to RU 2004127246;

[5] Equivalent to TW 478258 and TW 454391.

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

1248907-1

Electronic Acknowledgement Receipt	
EFS ID:	7415636
Application Number:	11974381
International Application Number:	
Confirmation Number:	4314
Title of Invention:	Detection, avoidance and/or correction of problematic puncturing patterns in parity bit streams used when implementing turbo codes
First Named Inventor/Applicant Name:	Philip J. Pietraski
Customer Number:	24374
Filer:	Robert Solomon/Carey Kulp
Filer Authorized By:	Robert Solomon
Attorney Docket Number:	I-2-0526.2US
Receipt Date:	14-APR-2010
Filing Date:	12-OCT-2007
Time Stamp:	17:08:07
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	ids.pdf	52100 6030f77173098b32bf25ad617833bf48ae9a4323	no	2
Warnings:					
Information:					

2	Information Disclosure Statement (IDS) Filed (SB/08)	pto1449.pdf	58555 42c723cb07505d9d8d1a0fb27554c0c7c272440c	no	4

Warnings:	
Information:	
This is not an USPTO supplied IDS fillable form	
Total Files Size (in bytes):	110655

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the PATENT APPLICATION of:	
	Pietraski et al.
Application No.:	11/974,381
Confirmation No.:	4314
Filed:	October 12, 2007
For: DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	
Group:	2112
Examiner:	Jacques H. Louis Jacques

Our File:	I-2-0526.2US
Date:	April 14, 2010

INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment (via EFS)
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Further to Applicants' Duty of Disclosure pursuant to 37 C.F.R. §1.56, Applicants wish to bring to the Examiner's attention the material cited on the enclosed Form PTO-1449.

The listed references include references previously cited in this application. Newly cited documents are indicated by an asterisk (*) on the enclosed Form PTO-1449. Pursuant to 37 C.F.R. §1.98(a)(2)(ii), copies of the newly cited U.S. publications and/or patent documents have not been included.

This Application is a continuation of Non-Provisional Application No. 10/725,779, filed on December 2, 2003, which issued on November 6, 2007 as U.S. Patent No. 7,293,217, which claims priority from Provisional Application No. 60/494,404, which was filed on August 11, 2003, Provisional Application No. 60/434,232, which was filed on December 16, 2002, Provisional Application No. 60/444,068, which was filed on January 30, 2003, and Provisional Application No. 60/470,921, which was filed on May 15, 2003.

It is respectfully requested that the Examiner consider these documents and return an initialed copy of the Form PTO-1449 indicating consideration of the cited materials.

Respectfully submitted,

Pietraski et al.

By_/Wesley T. McMichael/_____
Wesley T. McMichael
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(215) 568-6400

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30 South 17th Street
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WTM/pck
Enclosure

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use several sheets if necessary)	ATTY. DOCKET NO. I-2-0526.2US	SERIAL NO. 11/974,381
	APPLICANT Pietraski et al.	
	FILING DATE October 12, 2007	GROUP 2112

U.S. PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
		6,370,669	04/2002	Eroz et al.			
		6,601,214	07/2003	Hammons, Jr.			
		6,622,281	09/2003	Yun et al.			
		6,665,813	12/2003	Forsman et al.			
		7,076,726	07/2006	Yun et al.			
		2002/0027956	03/2002	Lee et al.			
		2002/0141433	10/2002	Kwon et al.			
		2003/0007476	01/2003	Kim et al.			

FOREIGN PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
		00/065446	06/2005	WO				
		00/011791	03/2000	WO			X[1]	
		00/041343	07/2000	WO			X[2]	
		02/033910	04/2002	WO			X[3]	
		03/069784	08/2003	WO			X[4]	

OTHER DOCUMENTS

EXAMINER INITIAL		DESCRIPTION (Including Author, Title, Date, Pertinent Pages, Etc.)
	*	"Universal Mobile Telecommunications System (UMTS); Multiplexing and channel coding (FDD); (3GPP TS 25.212 version 5.1.0 Release 5)," ETSI TS 125 212 V5.1.0 (June 2002).
		INTERDIGITAL, "Turbo-Coding And Pubcturing Interactions On HS-DSCH In R5 HSDPA", TSG-RAN Working Group 1 Meeting #32, R1-030444, (Paris, France 19-23 May 2003).
		Mo et al., "Analysis of Puncturing Pattern for High Rate Turbo Codes," IEEE International, 0-7803-5538-5/99, 1999, pgs. 547-550.

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use several sheets if necessary)	ATTY. DOCKET NO. I-2-0526.2US	SERIAL NO. 11/974,381
	APPLICANT Pietraski et al.	
	FILING DATE October 12, 2007	GROUP 2112

EXAMINER INITIAL		DESCRIPTION (Including Author, Title, Date, Pertinent Pages, Etc.)
		SIEMENS ET AL., "HSDPA For The 1,28 Mcps TDD Option – A-VRC Test Methodology And Simulation Assumptions", TSG-RAN Working Group 4 (Radio) Meeting #26, R4-030223, (Madrid, Spain 17-21 February 2003).
		SIEMENS, "Turbo Coder Irregularities In HSDPA", 3GPP TSG-RAN Working Group 1 #32, Toc R1-030421, (Paris, France 19-23 May 2003).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (FDD) (Release 6)", 3GPP TS 25.212 V6.1.0 (March 2004).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 6)", 3GPP TS 25.222 V6.0.0 (December 2003).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Channel Coding And Multiplexing Examples (Release 4)", 3GPP TS 25.944 V4.1.0 (June 2001).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) Protocol Specification (Release 5)", 3GPP TS 25.321 V5.6.0 (September 2003).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; MAC Protocol Specification (Release 5)", 3GPP TS 25.321 V5.2.0 (September 2002).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) Protocol Specification (Release 4)", 3GPP TS 25.321 V4.9.0 (September 2003).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; MAC Protocol Specification (Release 4)", 3GPP TS 25.321 V4.6.0 (September 2002).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) Protocol Specification (Release 1999)", 3GPP TS 25.321 V3.16.0 (September 2003).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; MAC Protocol Specification (Release 1999)", 3GPP TS 25.321 V3.13.0 (September 2002).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Channel Coding And Multiplexing Samples (Release 1999)", 3GPP TR 25.944 V3.5.0 (June 2001).

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	APPLICANT Pietraski et al.	
	FILING DATE October 12, 2007	GROUP 2112

EXAMINER INITIAL		DESCRIPTION (Including Author, Title, Date, Pertinent Pages, Etc.)
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		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (FDD) (Release 5)", 3GPP TS 25.212 V5.4.0 (March 2003).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (FDD) (Release 5)", 3GPP TS 25.212 V5.6.0 (September 2003).
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		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 1999)", 3GPP TS 25.222 V3.8.0 (March 2002).
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		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 4)", 3GPP TS 25.222 V4.5.0 (September 2002).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 4)", 3GPP TS 25.222 V4.6.0 (December 2002).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.2.1 (October 2002).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.4.0 (March 2003).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.5.0 (June 2003).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; High Speed Downlink Packet Access: Physical Layer Aspects (Release 5)," 3GPP TR 25.858 V5.0.0 (March 2002).

X[1] Equivalent to RU 2190296

X[2] Equivalent to RU 2185025

EXAMINER	DATE CONSIDERED

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FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use several sheets if necessary)	ATTY. DOCKET NO. I-2-0526.2US	SERIAL NO. 11/974,381
	APPLICANT Pietraski et al.	
	FILING DATE October 12, 2007	GROUP 2112

X[3] Equivalent to RU 2239292

X[4] Equivalent to RU 2004127246

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Electronic Acknowledgement Receipt	
EFS ID:	6642007
Application Number:	11974381
International Application Number:	
Confirmation Number:	4314
Title of Invention:	Detection, avoidance and/or correction of problematic puncturing patterns in parity bit streams used when implementing turbo codes
First Named Inventor/Applicant Name:	Philip J. Pietraski
Customer Number:	24374
Filer:	Robert Solomon/Carey Kulp
Filer Authorized By:	Robert Solomon
Attorney Docket Number:	I-2-0526.2US
Receipt Date:	15-DEC-2009
Filing Date:	12-OCT-2007
Time Stamp:	17:04:53
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	NPL Documents	ETSI.pdf	2516458 39d4976c136222ebd998686313d43089d69f278c	no	76
Warnings:					
Information:					

2	Transmittal Letter	IDS.pdf	53195 779b00a65a160b2c0fdc9bcb80a7b949b2851182	no	2
Warnings:					
Information:					
3	Information Disclosure Statement (IDS) Filed (SB/08)	PTO14492.pdf	24948 c114fcfc0b9c6a76e966280a5b64e868135754f0	no	4
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
			Total Files Size (in bytes):	2594601	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
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<u>National Stage of an International Application under 35 U.S.C. 371</u>
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<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the PATENT APPLICATION of:	
	Pietraski et al.
Application No.:	11/974,381
Confirmation No.:	4314
Filed:	October 12, 2007
For: DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	
Group:	2112
Examiner:	Jacques H. Louis Jacques

Our File:	I-2-0526.2US
Date:	December 15, 2009

INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment (via EFS)
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Further to Applicants' Duty of Disclosure pursuant to 37 C.F.R. §1.56, Applicants wish to bring to the Examiner's attention the material cited on the enclosed Form PTO-1449.

The listed references include references previously cited in this application. Newly cited documents are indicated by an asterisk (*) on the enclosed Form PTO-1449. Copies of the newly cited documents are enclosed.

This application is a continuation of Non-Provisional Application No. 10/725,779, filed on December 2, 2003, which issued on November 6, 2007 as U.S. Patent No.

7,293,217, which claims priority from Provisional Application No. 60/494,404, which was filed on August 11, 2003, Provisional Application No. 60/434,232, which was filed on December 16, 2002, Provisional Application No. 60/444,068, which was filed on January 30, 2003, and Provisional Application No. 60/470,921, which was filed on May 15, 2003.

It is respectfully requested that the Examiner consider these documents and return an initialed copy of the Form PTO-1449 indicating consideration of the cited materials.

Respectfully submitted,

Pietraski et al.

By_/Wesley T. McMichael/_____
Wesley T. McMichael
Registration No. 56,982
(215) 568-6400

Volpe and Koenig, P.C.
United Plaza, Suite 1600
30 South 17th Street
Philadelphia, PA 19103

WTM/pck
Enclosures (2)

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the PATENT APPLICATION of:	
	Pietraski et al.
Application No.:	11/974,381
Confirmation No.:	4314
Filed:	October 12, 2007
For: DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	
Group:	2112
Examiner:	Jacques H. Louis Jacques

Our File:	I-2-0526.2US
Date:	May 29, 2009

INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment (via EFS)
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Examiner:

Further to Applicants' Duty of Disclosure pursuant to 37 C.F.R. §1.56, Applicants wish to bring to the Examiner's attention the material cited on the enclosed Form PTO-1449.

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Respectfully submitted,

Pietraski et al.

By_/Scott Wolinsky/_____
Scott Wolinsky
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(215) 568-6400

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United Plaza, Suite 1600
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Philadelphia, PA 19103

SW/pck
Enclosures (2)

FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use several sheets if necessary)	ATTY. DOCKET NO. I-2-0526.2US	SERIAL NO. 11/974,381
	APPLICANT Pietraski et al.	
	FILING DATE October 12, 2007	GROUP 2112

U.S. PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
		6,370,669	04/2002	Eroz et al.			
		6,601,214	07/2003	Hammons, Jr.			
		6,622,281	09/2003	Yun et al.			
		6,665,813	12/2003	Forsman et al.			
		7,076,726	07/2006	Yun et al.			
		2002/0027956	03/2002	Lee et al.			
		2002/0141433	10/2002	Kwon et al.			
		2003/0007476	01/2003	Kim et al.			

FOREIGN PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
		00/065446	06/2005	WO				
		00/011791	03/2000	WO			X[1]	
		00/041343	07/2000	WO			X[2]	
		02/033910	04/2002	WO			X[3]	
		03/069784	08/2003	WO			X[4]	

OTHER DOCUMENTS

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		Mo et al., "Analysis of Puncturing Pattern for High Rate Turbo Codes," IEEE International, 0-7803-5538-5/99, 1999, pgs. 547-550.
		SIEMENS ET AL., "HSDPA For The 1,28 Mcps TDD Option – A-VRC Test Methodology And Simulation Assumptions", TSG-RAN Working Group 4 (Radio) Meeting #26, R4-030223, (Madrid, Spain 17-21 February 2003).

EXAMINER	DATE CONSIDERED

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FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use several sheets if necessary)	ATTY. DOCKET NO. I-2-0526.2US	SERIAL NO. 11/974,381
	APPLICANT Pietraski et al.	
	FILING DATE October 12, 2007	GROUP 2112

EXAMINER INITIAL		DESCRIPTION (Including Author, Title, Date, Pertinent Pages, Etc.)
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		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Channel Coding And Multiplexing Examples (Release 4)", 3GPP TS 25.944 V4.1.0 (June 2001).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) Protocol Specification (Release 5)", 3GPP TS 25.321 V5.6.0 (September 2003).
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	APPLICANT Pietraski et al.	
	FILING DATE October 12, 2007	GROUP 2112

EXAMINER INITIAL		DESCRIPTION (Including Author, Title, Date, Pertinent Pages, Etc.)
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (FDD) (Release 5)", 3GPP TS 25.212 V5.4.0 (March 2003).
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X[1] Equivalent to RU 2190296

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X[3] Equivalent to RU 2239292

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Electronic Acknowledgement Receipt

EFS ID:	5420937
Application Number:	11974381
International Application Number:	
Confirmation Number:	4314
Title of Invention:	Detection, avoidance and/or correction of problematic puncturing patterns in parity bit streams used when implementing turbo codes
First Named Inventor/Applicant Name:	Philip J. Pietraski
Customer Number:	24374
Filer:	Robert Solomon/Carey Kulp
Filer Authorized By:	Robert Solomon
Attorney Docket Number:	I-2-0526.2US
Receipt Date:	29-MAY-2009
Filing Date:	12-OCT-2007
Time Stamp:	14:39:20
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed (SB/08)	IDSFiled.pdf	94509 fb9ae6e7bab588027bce745d481d022fe88073b8	no	5

Warnings:	
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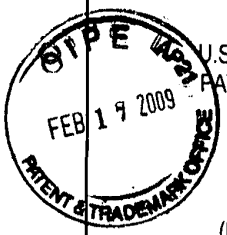
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		00/041343	07/2000	WO			X[2]	
		02/033910	04/2002	WO			X[3]	
		03/069784	08/2003	WO			X[4]	

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	APPLICANT Pietraski et al.	
	FILING DATE October 12, 2007	GROUP 2112

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		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 4)", 3GPP TS 25.222 V4.5.0 (September 2002).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 4)", 3GPP TS 25.222 V4.6.0 (December 2002).
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X[1] Equivalent to RU 2190296

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : G06F 11/10 — A1

(11) International Publication Number: **WO 00/65446**

(43) International Publication Date: 2 November 2000 (02.11.00)

(21) International Application Number: PCT/US00/11221

(22) International Filing Date: 26 April 2000 (26.04.00)

(30) Priority Data:
60/131,315 27 April 1999 (27.04.99) US

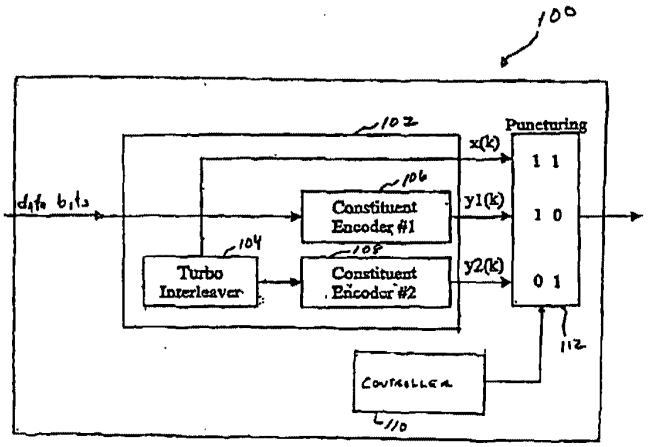
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(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: A SYSTEM AND METHOD EMPLOYING A RATE MATCHING ALGORITHM IN A COMMUNICATION NETWORK



(57) Abstract

A system and method employing a rate matching algorithm for providing an optimized pattern for puncturing parity bits of a turbo encoded data word of a given rate to produce a turbo encoded data word of a desired lower rate, to thus eliminate bits from said turbo encoded data word to be transmitted by a transmitter (100). The system and method determine a final amount of bits to be transmitted in the encoded data word, and determine, based on the final amount of bits in relation to the original number of bits in the encoded data word, the number of parity bits to be eliminated from transmission in the encoded data word. Because the parity bits typically have been inserted into the encoded data word by different encoders, the system and method uses a rate matching algorithm to provide an optimized pattern for puncturing the parity bits so that substantially the same number of parity bits provided by each encoder (106, 108) are punctured.

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A System and Method Employing a Rate Matching Algorithm in a Communication Network

The present invention claims benefit under 35 U.S.C. § 119(e) of a U.S. provisional application of A Roger Hammons entitled "Rate Matching Algorithm Providing Near Optimal Puncturing Patterns for Turbo Codes", Serial No. 60/131,315, filed April 27, 1999, the entire contents of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to a system and method employing a rate matching algorithm for providing optimized puncturing patterns for turbo encoded data in a communications network. More particularly, the present invention relates to a system and method employing a rate matching algorithm for providing an optimized pattern for puncturing parity bits of a turbo encoded data word of a given rate to produce a turbo encoded data word of a desired lower rate.

Description of the Related Art:

Many communications devices, such as those used in satellite-based or terrestrial telecommunications networks, employ encoders for encoding data prior to transmission to increase the integrity of the transmitted data and thus reduce data receipt errors. One type of encoder suitable for use in data transmitters is referred to as a turbo encoder. A turbo encoder

typically includes one or more constituent encoders which insert in the outgoing data stream one or more parity bits for each information-bearing data bit (information bit).

The number of parity bits per data bit in the outgoing data stream indicates the rate at which the outgoing data stream is encoded. For example, a rate 1/3 systematically-encoded data stream includes the input information-bearing data bits, as well as two parity bits per each information bit. In other words, the length of a data stream that is rate 1/3 encoded is increased by a factor of three. Similarly, a rate 1/2 systematically-encoded data stream includes one parity bit per each real information bit in the data stream. Hence, the length of a data stream that is rate 1/2 encoded is increased by a factor of two.

Due to data capacity limitations that may be present in certain communications networks, it is often necessary to decrease the rate and hence, the length, of a rate encoded data stream. For example, many communications networks transmit data in data packets or frames of a fixed size, which are transmitted in a time-division multiple access (TDMA) transmission scheme. Due to the fixed length of a data frame, a rate 1/3 data stream may be too long to fit within one data frame. However, the length of a data frame may be sufficient to contain a shorter rate 1/2 data stream. Hence, it may be desirable to decrease a rate 1/3 data stream to a rate 1/2 data stream so the data stream can be transmitted within one data frame.

One method of decreasing the rate of a data stream is referred to as puncturing the data stream. When a data stream is punctured, certain bits of the data stream are eliminated from the data stream transmission. For example, if a rate 1/3 data stream having a length of 3000 bits is punctured to a rate 1/2 data stream having a length of 2000 bits, 1000 bits of the rate 1/3 data stream are not transmitted.

In many systems employing convolutional coding, puncturing is ordinarily performed as a part of channel encoding so that optimal or nearly optimal puncturing patterns can be applied. In certain code-division multiple access (CDMA) systems employing convolutional encoding, the puncturing is performed by a generic "rate matching" function apart from the encoder, in order to simplify multiplexing of many disparate data streams onto a common set of physical channels. In such an environment, the available payload would not be known at the encoder and the required puncturing patterns would be complex. For rate 1/3 turbo codes, in which the turbo encoder produces two parity bits for every systematic information bit as discussed above, it is preferable to avoid puncturing any of the systematic bits and to spread

the puncturing between constituent encoders as evenly as possible. However, known rate matching algorithms for systems using convolutional codes fail to meet the above mentioned turbo code puncturing guidelines.

Therefore, a need exists for a method and system for providing an algorithm for evenly puncturing parity bits of a turbo encoded data stream without puncturing any systematic data bits of the data stream.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a system and method employing a rate matching algorithm for providing optimized puncturing patterns for turbo encoded data in a communications network.

Another object of the present invention is to provide a system and method employing a rate matching algorithm for providing an optimized pattern for puncturing parity bits of a turbo encoded data word of a given rate to produce a turbo encoded data word of a desired lower rate, to thus eliminate bits from said turbo encoded data word to be transmitted by a transmitter.

A further object of the present invention is to provide a system and method employing a rate matching algorithm for providing optimized patterns for puncturing parity bits that have been inserted into a turbo encoded data word by different encoders so that substantially the same amount of parity bits provided by each encoder are punctured.

These and other objects of the present invention are substantially achieved by providing a system and method for puncturing bits of an encoded data word to reduce a total number of bits in the encoded data word to be transmitted by a transmitter of a communications system. The bits include information bits and parity bits. The system and method operate to determine a final desired number of bits to be transmitted in the encoded data word, and to determine a respective number of parity bits associated with each respective number of information bits. The system and method establish a first variable for identifying positions of the information bits in the data word, and establish a respective parity variable associated with each respective number of parity bits. For example, if the encoded data word

is rate 1/3 encoded, two parity bits are associated with each information bit. Therefore, the system and method will establish two parity variables.

The system and method then operate to eliminate certain parity bits from transmission in the encoded word based on values of the first variable and each respective parity variable so that the final desired number of bits remain in the encoded data word. In doing so, the system and method organizes the bits into a systematic group and one or more parity groups. The system and method selects certain groups based on the final number of bits and eliminates at least one parity bit from each of the selected groups. To do this, the system and method periodically changes the values of the first variable and each respective parity variable based on at least one constant which has been determined based on the final amount, and determines whether to eliminate any of the parity bits of a particular group during each period in which the values of the first variable and each respective parity variable are changed.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects, advantages and novel features of the invention will be more readily appreciated from the following detailed description when read in conjunction with the accompanying drawings, in which:

Fig. 1 is a conceptual block diagram of a user terminal employing a system and method according to an embodiment of the present invention;

Fig. 2 is a flowchart illustrating exemplary processing steps performed in accordance with a puncturing algorithm provided by the system and method employed in the user terminal shown in Fig. 1; and

Fig. 3 is a flowchart illustrating exemplary processing steps performed in accordance with another puncturing algorithm provided by the system and method employed in the user terminal shown in Fig. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a conceptual block diagram illustrating an example of a transmitter 100, for use in a communications network such as a satellite-based or terrestrial telecommunications

network, and which employs a system and method according to an embodiment of the present invention. As illustrated, the transmitter 100 includes a turbo encoder 102 comprising a turbo interleaver 104 and constituent encoders 106 and 108.

A controller 110 for performing a puncturing algorithm according to an embodiment of the present invention applies an appropriate puncturing pattern to the output of the turbo encoder 102 at a puncturing position 112 as will now be described. It is noted that the turbo encoder 102 and controller 110 could be implemented as software in a digital signal processor (DSP) or as logic circuitry in a very large scale integration (VLSI) configuration. It is also possible for the turbo encoder 102, for example, to be implemented as circuitry in a VLSI configuration while the controller 110 resides in software in a DSP, or vice-versa.

Like conventional convolutional codes, turbo codes are capable of supporting variable channel code rates because the output of the encoder 102 can be punctured by applying simple periodic puncturing patterns. This process is illustrated in Fig. 1 as discussed above, which shows a standard turbo encoder 102 followed by a puncturing function applied at puncturing position 112. The puncturing function is represented by a binary array governing the puncturing of the coded bits in time.

As can be appreciated by one skilled in the art, the output of the turbo encoder is multiplexed in time. That is, if x(k) represents the k-th input bit and y1(k) and y2(k) represent the corresponding parity bits produced by the two constituent encoders 106 and 108, then the rate 1/3 turbo code produces the following sequence of coded bits: x(1), y1(1), y2(1); x(2), y1(2), y2(2);... x(L), y1(L), y2(L). A well-known puncturing pattern for producing a rate 1/2 turbo code from a rate 1/3 turbo encoder is shown in Fig. 1. As illustrated, the output of the encoder 102 after puncturing at the puncturing component 112 is given by the sequence:

$$x(1), y1(1); x(2),y2(2) ;x(3),y1(3);....$$

corresponding to the following linear periodic puncturing pattern: 110 101. This coding technique has been extensively investigated in the literature and gives excellent performance.

Specifically, in the puncturing array shown at puncturing position 112, the value "1" indicates transmission of the corresponding coded bit, and the value "0" indicates that the corresponding coded bit is not transmitted. The pattern is applied periodically to the outputs

of the constituent encoders. Accordingly, in the first group of three bits consisting of one systematic data bit and two parity data bits, the parity bit provided by constituent encoder 106 is punctured. However, in the second group of three bits, the parity bit provided by constituent encoder 108 is punctured.

The rate matching algorithm according to an embodiment of the present invention that will now be discussed provides optimal or nearly optimal puncturing of turbo coded data when performed after the channel encoding. This algorithm has low implementation complexity yet succeeds in spreading the puncturing in a balanced manner between constituent encoders.

The following variables represent the characteristics of the encoded data:

Encoded data (code word):	c[0], c[1], c[2], . . . , c[Nc-1]
Code word length (bits):	Nc
Available payload (bits):	Ni
Channel code rate:	R

It is assumed that Ni < Nc, so that puncturing is required to make encoded data fit the available payload. For illustrative purposes, it is also assumed in this example that input code rate R = 1/3 and that the encoded data are presented in the customary fashion for a rate 1/3 turbo code, that is, a systematic bit followed by the corresponding parity bit from the first constituent encoder followed by the corresponding parity bit from the second constituent encoder followed by the next systematic bit, and so on. Thus, the coded bits c[3i] are the systematic bits, the coded bits c[3i+1] are the parity bits produced by the first constituent encoder 106, and the coded bits c[3i+2] are the parity bits produced by the second constituent encoder 108.

The following represents a Pseudo-Design Language Description (using C-language conventions) of the algorithm according to an embodiment of the present invention, taking into account the variables defined above:

```
D = Ni - Nc;
P = 2 * Nc / 3;
d = D / gcd( D, P );
p = P / gcd( D, P );

s1 = 0;
s2 = ((int)(p/2) * d) % p;

for( i=0; i<P; i=i+2 )
{  m = 3 * i / 2;
 s1 += d;
 if( s1 >= p ) {     Puncture c[m+1]; s1 -= p;  }
 s2 += d;
 if( s2 >= p ) {Puncture c[m+2]; s2 -= p;  }}
```

It is noted that in the above pseudo-code, the integer function gcd (x, y) returns the greatest common divisor of the integers x and y, the term "+=" means to increase the value of the variable on the left side of the term (e.g., s1) by the value of the variable on the right side of the term (e.g., d), the term "-=" means to decrease the value of the variable on the left side of the term (e.g., s1) by the value of the variable on the right side of the term (e.g., p), and the term "%" represents modulo division. From the pseudo-code description, the following basic design principles are clear: (1) Each parity stream is punctured as uniformly as possible by using a pattern that removes on average d of every p parity bits; (2) The puncturing pattern for the second stream of parity bits (from second constituent encoder) is the same as that of the first but offset from the first by roughly 1/2 the length of the pattern.

These design principles are implemented very simply via a pair of modulo-p accumulators, s1 and s2, one for each parity stream. The accumulators are incremented by d for each encoded information bit and reduced by p when necessary to prevent overflow. Reduction by p triggers the puncturing of the corresponding parity bit from that stream. The puncture patterns for the two constituent encoders are effectively staggered by using different

initializations for the two accumulators.

The operation of the controller 110 that executes the algorithm specified by the pseudo code described above can be better appreciated in view of the flowchart shown in Fig. 2. As shown in step 1000, the controller 110 initializes the variables discussed above, namely, D, P, d, p, s1 and s2. The processing then continues to step 1010 where it enters the "For" loop shown in the pseudo code. Specifically, the processing determines in step 1010 whether the value of "i", the loop counting variable, is less than P. If not, this is an indication that all groups of the systematic bits and their associated parity bits (in this example, 3 bit groups), have been processed, and the processing proceeds to step 1020 and ends.

However, if the value of i is less than the value of P, the processing proceeds to step 1030, where the values of variables "m" and "s1" are changed according to the equations in the pseudo code. It is noted that the value of s1 is incremented by the value of d. The processing then continues to step 1040 where it is determined whether the new value of s1 is greater than or equal to the value of p. If so, the processing proceeds to step 1050 where the parity bit output by constituent encoder 106 is punctured. The processing then proceeds to step 1060 where the value of s1 is decremented by the value of p, and the processing continues to step 1070. It is noted, however, if it is determined in step 1040 that the new value of s1 is not greater than or equal to the value of p, the processing proceeds from step 1040 to step 1070, skipping steps 1050 and 1060.

In step 1070, the processing increments the value of s2 by the value of d. The processing the proceeds to step 1080 where it is determined whether the new value of s2 is greater than or equal to the value of p. If so, the processing proceeds to step 1090 where the parity bit output by constituent encoder 108 is punctured. The processing then proceeds to step 1100 where the value of s2 is decremented by the value of p, and the processing returns to step 1010. It is noted, however, if it is determined in step 1080 that the new value of s2 is not greater than or equal to the value of p, the processing proceeds from step 1080 to step 1010, skipping steps 1090 and 1100. When the processing returns to step 1010, the value of "i" is incremented in step 1110 as indicated, and the processing repeats as discussed above.

The following tables represent examples of the puncturing pattern achieved by the pseudo code and operation of the controller 110 as described above. In these examples, the input code rate is R = 1/3. Table 1 below illustrates an example of the ideally balanced

puncturing pattern for rate 1/2 as produced by the rate matching algorithm, with d = 1 and p = 2.

Table 1: Example of Puncturing Pattern for Rate 1/2

i	m	s1 0	s2 1	Puncturing Pattern c[m]	c[m+1]	c[m+2]
0	0	1	2	1	1	0
2	3	2	1	1	0	1

Table 2 below illustrates an example of the ideally balanced puncturing pattern for code rate 2/3 as produced by the rate matching algorithm, with d = 3 and p = 4.

Table 2: Example of Puncturing Pattern for Rate 2/3

i	m	s1 0	s2 2	Puncturing Pattern c[m]	c[m+1]	c[m+2]
0	0	3	5	1	1	0
2	3	6	4	1	0	0
4	6	5	3	1	0	1
6	9	4	6	1	0	0

Table 3 below illustrates an example of the ideally balanced puncturing pattern for code rate 5/12 as produced by the rate matching algorithm, with d = 3 and p = 10.

Table 3: Example of Puncturing Pattern for Rate 5/12

i	m	s1 0	s2 5	Puncturing Pattern c[m]	c[m+1]	c[m+2]
0	0	3	8	1	1	1
2	3	6	11	1	1	0
4	6	9	4	1	1	1
6	9	12	7	1	0	1
8	12	5	10	1	1	0
10	15	8	3	1	1	1
12	18	11	6	1	0	1
14	21	4	9	1	1	1
16	24	7	12	1	1	0
18	27	10	5	1	0	1

For purposes of illustration only, the rate matching algorithm is discussed above in relation to a rate 1/3 turbo code, produced by a turbo encoder 102 comprising two constituent encoders 106 and 108, each of which produces one parity bit per input information bit. However, as will now be demonstrated, the algorithm is applicable to other code rates.

For example, consider a case in which the code rate is R = k/n (every k information bits produces r = n-k parity bits) and the puncturing is to be spread over the r parity streams in a balanced manner. The following modification of the rate matching algorithm is a straightforward adaptation that conforms to the basic concept and meets the balanced puncturing objective.

The following represents a pseudo-design language description (using C-language conventions) of the algorithm according to another embodiment of the present invention, taking into account the variables Ni, Nc and R as defined above, and that encoded data (code word) is represented by the terms: c[0], c[1], c[2], . . . , c[Nc-1] as discussed above:

```
D = Ni - Nc;
P = Nc * (1-R);
r = n – k;
d = D / gcd( D, P );
p = P / gcd( D, P );

for( j=0; j<r; ++j )  s[j] = (j * (int)(p/r) * d) % p;

for( i=0; i<P; i=i+r ) {
  m = (n * i)/r;
  for( j=0; j<r; ++j ){
    s[j] += d;
    if( s[j] >= p ) {
      Puncture c[m+j+k];
      s[j] -= p;
    }
  }
}
```

The operation of the controller 110 executing the pseudo code described above can be better appreciated in view of the flowchart shown in Fig. 3. As shown in step 1200, the controller 110 initializes the variables discussed above, namely, D, P, r, d and p. The processing then continues to step 1210 where it enters the "For" loop shown in the pseudo code to initialize the accumulators s[j] as indicated. Specifically, the processing determines in step 1210 whether the value of "j", the loop counting variable, is less than r. If so, the processing proceeds to step 1220, where the values of variable "s[j]" is initialized according to the equation in the pseudo code. The processing repeats as long as j is less than r, with j being incremented by "1" each time the processing returns to step 1210 (as represented by the term "++j" in the pseudo code) and before the comparison of j to r is made.

Once it is determined in step 1210 that j is not less than r, the processing proceeds to

step 1230 where it is determined whether the value of "i", a loop counter, is less than the value of P. It is noted that the first time this step is reached, the value of i is initialized to zero. If the value of i is less than the value of P, the processing proceeds to step 1240 where the value of "m" is set according to the equation in the pseudo code.

The processing then proceeds to step 1250 where it is determined whether the value of j is less than the value of r. It is noted that the first time this step is reached after each time the processing performs step 1240, the value of j is initialized to zero. If the value of j is less than the value of r, the processing proceeds to step 1260 where the value of variable s[j] is changed as indicated in the pseudo code. The processing proceeds the step 1270 where it is determined whether the new value of s[j] is greater than or equal to the value of p. If the value of s[j] is greater than or equal to the value of p, the bit c[m+j+k] is punctured in step 1280, as indicated in the pseudo code. The processing then proceeds to step 1290, where the value of s[j] is decremented by the value of p, as indicated in the pseudo code. The processing then returns to step 1250, and repeats as discussed above.

When the processing returns to step 1250, the value of j is incremented in step 1295 as indicated in the pseudo code before the comparison of j to r is made. If it is determined in step 1250 that the value of j is not less that or equal to the value of r, the processing returns to step 1230 without performing steps 1260 through 1290. In returning to step 1230, the value of i is incremented in step 1255 as indicated in the pseudo code before the comparison of i to P is made. If the value of i is less than P, the processing proceeds to step 1240 where the value of m is set as discussed above, and then to step 1250 where the processing relating to this step as discussed above is performed. It is noted that as mentioned above, when the processing proceeds to step 1250 from step 1240, the value of j is initialized to zero. However, if it is determined in step 1230 that the value of i is not less than P, it is determined that the processing has been performed for all groups of bits (i.e., all groups of systematic bits and associated parity bits). The processing thus proceeds to step 1300 and ends.

It is noted that the staggering of the pattern could be done differently. For instance, the initialization of the accumulators s[j] could also be done as follows and yield a similar effect:

```
for( j=0; j<r; ++j )  s[j] = ((int)(j*p/r) * d) % p;
```

In fact, it is also possible under certain circumstances (e.g., if the number of punctured bits is divisible by the number of constituent encoders) for the staggers to all be the same since the turbo interleavers effectively randomize the puncturing over time. This would enable a simplified implementation in which one set of variables controls the puncturing of all constituent encoders' outputs. Optimization of the specific choice of staggers could also be done to best match the actual turbo codes and code rates of interest.

In another variation of the algorithm, it is noted that it is not necessary to treat all of the parity streams equally. In more complex turbo codes, in which, for example, the constituent encoders produce two or more parity bits per information bit, it may be preferable to puncture certain of the parity streams less than others. This can be accomplished using the above rate matching algorithm by making the values d and p functions of the parity stream j. The algorithm would then increment accumulator s[j] by d[j] modulo p[j], etc. The staggers would again be dependent on the parity stream and again could be non-uniform in this case.

As can be appreciated from the above description, the algorithms according to the invention meet the puncturing guidelines with low complexity. When rate matching is performed right after channel encoding, the puncturing pattern provided by the algorithm can be applied directly to the encoded data. When rate matching is performed after channel interleaving, the rate matching algorithm is preferably applied after first inverting the channel interleaving. It is also noted that the above algorithms can be applied to any system using turbo codes in which rate matching is performed apart from the channel encoder.

Although only a few exemplary embodiments of the present invention have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the following claims.

What is claimed is:

1. A method for puncturing bits of an encoded data word to reduce a total number of bits in said encoded data word to be transmitted by a transmitter of a communications system, said bits including information bits and parity bits, the method comprising the steps of:

determining a final amount of said bits to be transmitted in said encoded data word;

determining a respective number of said parity bits associated with each respective number of said information bits;

establishing a first variable for identifying positions of said information bits in said data word;

establishing a respective parity variable associated with each of said respective number of parity bits; and

eliminating certain of said parity bits from transmission in said encoded word based on values of said first variable and each said respective parity variable so that said final amount of bits remain in said encoded data word.

2. A method as claimed in claim 1, further comprising the step of:

organizing said bits into groups, each groups including an amount of said parity bits equal to said respective number of said parity bits and an amount of said information bits equal to said respective number of information bits.

3. A method as claimed in claim 2, wherein said eliminating step includes the step of:

selecting certain of said groups as selected groups based on said final number of bits; and

eliminating at least one of said parity bits from each of said selected groups.

4. A method as claimed in claim 1, wherein said eliminating step includes the steps of:

periodically changing said values of said first variable and each said respective parity

variable based on at least one constant which has been determined based on said final amount; and

determining whether to eliminate any of said parity bits during each period in which said values of said first variable and each said respective parity variable are changed.

5. A method as claimed in claim 1, wherein:

when said encoded word is rate k/n encoded, said each respective number of information bits equals k and said respective number of parity bits equals n minus k.

6. A method as claimed in claim 5, wherein:

when said encoded word rate is 1/3 encoded, said each respective number of information bits equals 1 and said respective number of parity bits equals 2; and

said parity variable establishing step establishes two of said respective parity variables.

7. A method as claimed in claim 1, wherein:

said encoded data word is a turbo encoded data word.

8. A computer readable medium of instructions, adapted to control a processor to puncture bits of an encoded data word to reduce a total number of bits in said encoded data word to be transmitted by a transmitter of a communications system, said bits including information bits and parity bits, the computer readable medium of instructions comprising:

a first set of instructions, adapted to control said processor to determine a final amount of said bits to be transmitted in said encoded data word;

a second set of instructions, adapted to control said processor to determine a respective number of said parity bits associated with each respective number of said information bits;

a third set of instructions, adapted to control said processor to establish a first variable for identifying positions of said information bits in said data word;

a fourth set of instructions, adapted to control said processor to establish a respective parity variable associated with each of said respective number of parity bits; and

a fifth set of instructions, adapted to control said processor to eliminate certain of said parity bits from transmission in said encoded word based on values of said first variable and

each said respective parity variable so that said final amount of bits remain in said encoded data word.

9. A computer readable medium of instructions as claimed in claim 8, further comprising:

a sixth set of instructions, adapted to control said processor to organize said bits into groups, each groups including an amount of said parity bits equal to said respective number of said parity bits and an amount of said information bits equal to said respective number of information bits.

10. A computer readable medium of instructions as claimed in claim 9, wherein said fifth set of instructions is further adapted to control said processor to:

select certain of said groups as selected groups based on said final number of bits; and

eliminate at least one of said parity bits from each of said selected groups.

11. A computer readable medium of instructions as claimed in claim 8, wherein said fifth set of instructions is further adapted to control said processor to:

periodically change said values of said first variable and each said respective parity variable based on at least one constant which has been determined based on said final amount; and

determine whether to eliminate any of said parity bits during each period in which said values of said first variable and each said respective parity variable are changed.

12. A computer readable medium of instructions as claimed in claim 8, wherein:

when said encoded word is rate k/n encoded, said each respective number of information bits equals k and said respective number of parity bits equals n minus k.

13. A computer readable medium of instructions as claimed in claim 12, wherein:

when said encoded word rate is 1/3 encoded, said each respective number of information bits equals 1 and said respective number of parity bits equals 2; and

said fourth set of instructions controls said processor to establish two of said respective

parity variables.

14. A computer readable medium of instructions as claimed in claim 8, wherein:

said encoded data word is a turbo encoded data word.

15. A system for puncturing bits of an encoded data word to reduce a total number of bits in said encoded data word to be transmitted by a transmitter of a communications system, said bits including information bits and parity bits, the system comprising:

a first determiner, adapted to determine a final amount of said bits to be transmitted in said encoded data word;

a second determiner, adapted to determine a respective number of said parity bits associated with each respective number of said information bits;

a first variable component, adapted to establish a first variable for identifying positions of said information bits in said data word;

a parity variable component, adapted to establish a respective parity variable associated with each of said respective number of parity bits; and

a bit eliminator, adapted to eliminate certain of said parity bits from transmission in said encoded word based on values of said first variable and each said respective parity variable so that said final amount of bits remain in said encoded data word.

16. A system as claimed in claim 15, further comprising:

a bit organizer, adapted to organize said bits into groups, each groups including an amount of said parity bits equal to said respective number of said parity bits and an amount of said information bits equal to said respective number of information bits.

17. A system as claimed in claim 16, wherein said bit eliminator is further adapted to:

select certain of said groups as selected groups based on said final number of bits; and

eliminate at least one of said parity bits from each of said selected groups.

18. A system as claimed in claim 15, wherein said bit eliminator is further adapted

to:

periodically change said values of said first variable and each said respective parity variable based on at least one constant which has been determined based on said final amount; and

determine whether to eliminate any of said parity bits during each period in which said values of said first variable and each said respective parity variable are changed.

19. A system as claimed in claim 15, wherein:

when said encoded word is rate k/n encoded, said each respective number of information bits equals k and said respective number of parity bits equals n minus k.

20. A system as claimed in claim 19, wherein:

when said encoded word rate is 1/3 encoded, said each respective number of information bits equals 1 and said respective number of parity bits equals 2; and

said parity variable establishing step establishes two of said respective parity variables.

21. A system as claimed in claim 15, wherein:

said encoded data word is a turbo encoded data word.

22. A system as claimed in claim 15, wherein:

at least one of said first determiner, said second determiner, said first variable component, said parity variable component, and said bit eliminator are employed in a VLSI configuration.

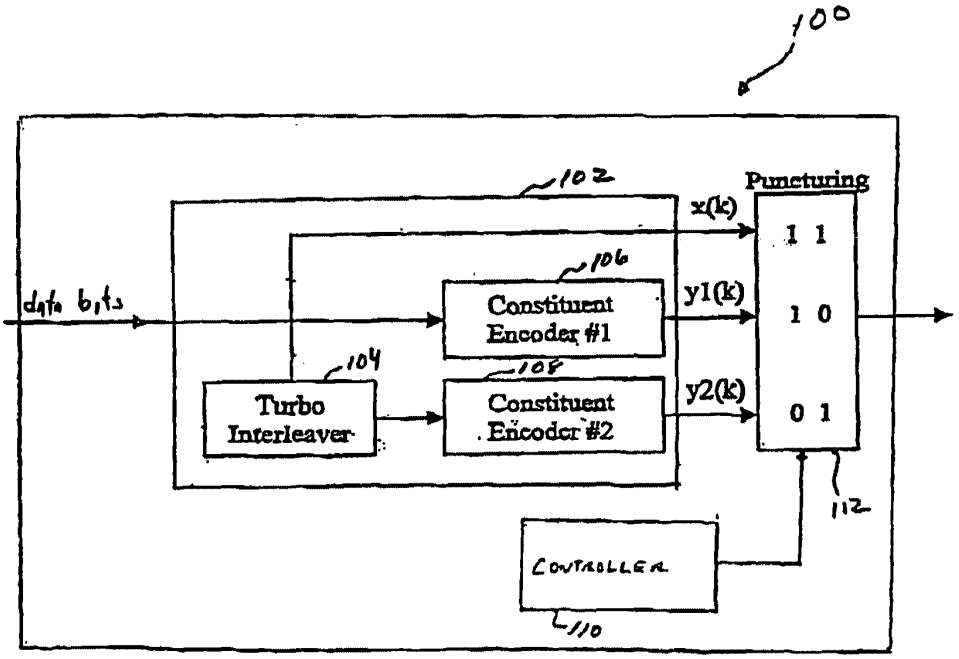

100
102
Puncturing
x(k)
1 1
106
data bits
Constituent Encoder #1
y1(k)
1 0
104
108
Turbo Interleaver
Constituent Encoder #2
y2(k)
0 1
112
CONTROLLER
110

FIG. 1

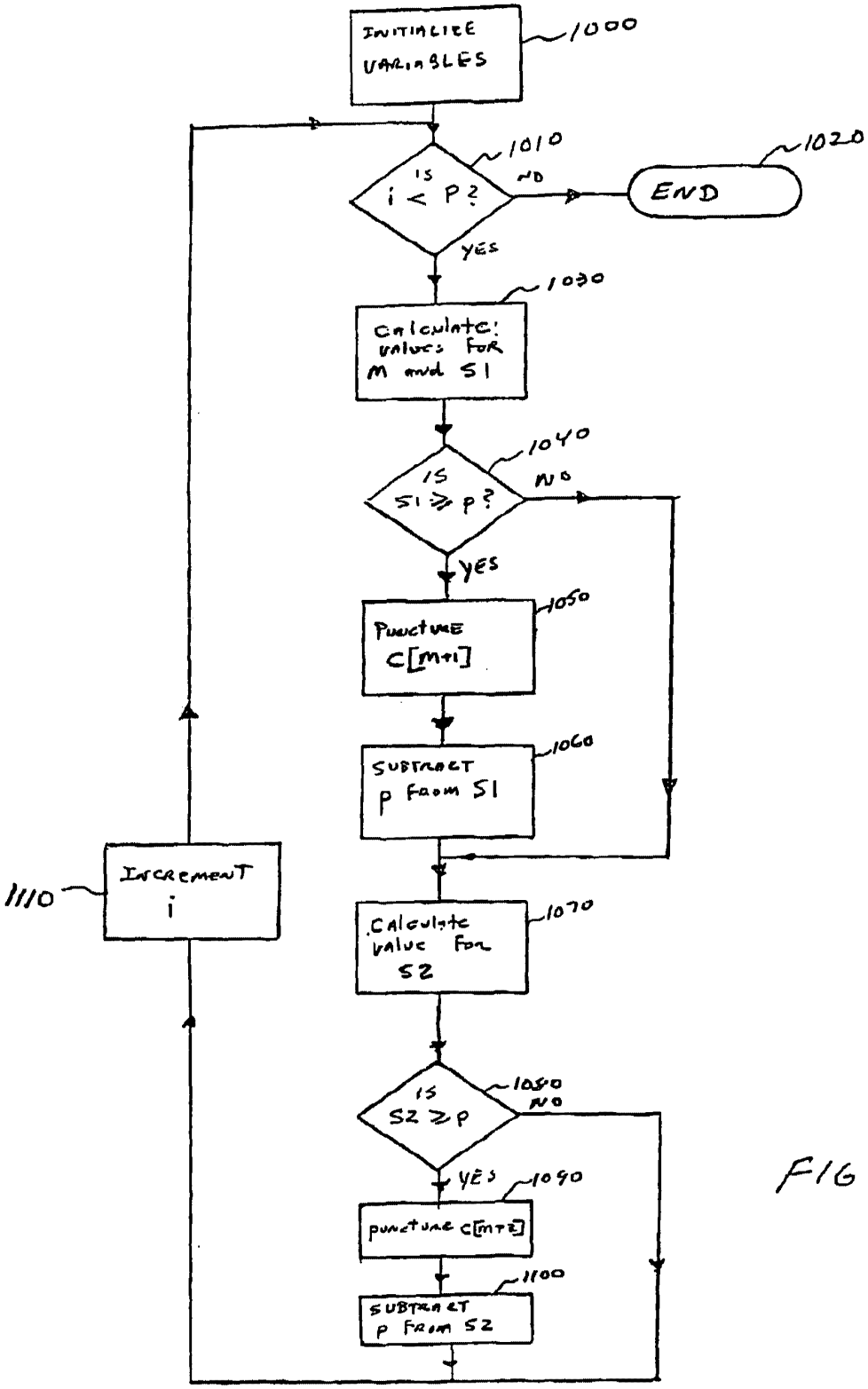

INITIALIZE VARIABLES
1000
1010
IS i < P ?
NO
END
1020
YES
1030
Calculate values FOR M and S1
1040
IS S1 ≥ P ?
NO
YES
1050
PUNCTURE C[M+I]
1060
SUBTRACT P FROM S1
1110
INCREMENT i
1070
CALCULATE VALUE FOR S2
1080
IS S2 ≥ P
NO
YES
1090
PUNCTURE C[M+I]
1100
SUBTRACT P FROM S2

FIG. 2

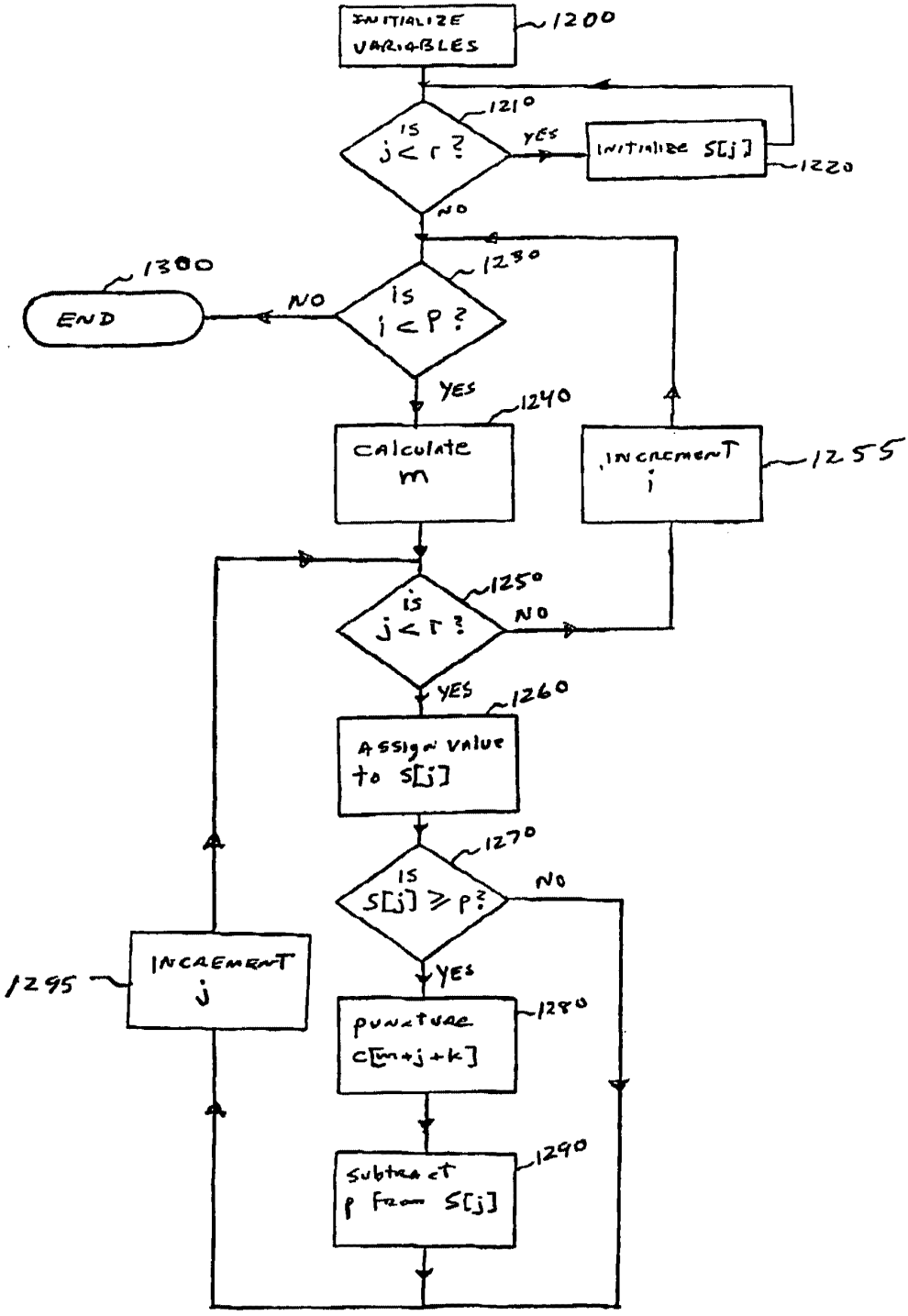

INITIALIZE VARIABLES
1200
IS j < r ?
1210
YES
INITIALIZE S[j]
1220
NO
1230
IS i < P ?
NO
END
1300
YES
1240
CALCULATE m
INCREMENT i
1255
IS j < r ?
1250
NO
YES
1260
ASSIGN VALUE TO S[j]
1270
IS S[j] ≥ P ?
NO
YES
PUNCTURE c[m+j+k]
1280
SUBTRACT P FROM S[j]
1290
INCREMENT j
1295

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/11221

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G06F 11/10
US CL : 714/790

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 714/790

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y,P	US 5,987,067 A (SONG) 16 November 1999, col. 1, lines 31-50, abstract.	1-22
Y,P	US 5,910,182 A (DENT et al) 08 June 1999, col. 2, lines 52-61, col. 3, lines 5-15, col. 11, lines 4-30.	1-22

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
18 JUNE 2000	18 SEP 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer Albert DeCady Telephone No. (703) 305-9595

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TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Total Number of Pages in This Submission

Application Number	11/974,381
Filing Date	October 12, 2007
First Named Inventor	Pietraski et al.
Art Unit	2112
Examiner Name	Not Yet Known
Attorney Docket Number	I-2-0526.2US

ENCLOSURES *(Check all that apply)*

- ☐ Fee Transmittal Form
  - ☐ Fee Attached
- ☐ Amendment/Reply
  - ☐ After Final
  - ☐ Affidavits/declaration(s)
- ☐ Extension of Time Request
- ☐ Express Abandonment Request
- ☒ Information Disclosure Statement
- ☐ Certified Copy of Priority Document(s)
- ☐ Reply to Missing Parts/ Incomplete Application
  - ☐ Reply to Missing Parts under 37 CFR 1.52 or 1.53
- ☐ Drawing(s)
- ☐ Licensing-related Papers
- ☐ Petition
- ☐ Petition to Convert to a Provisional Application
- ☐ Power of Attorney, Revocation Change of Correspondence Address
- ☐ Terminal Disclaimer
- ☐ Request for Refund
- ☐ CD, Number of CD(s) _____
  - ☐ Landscape Table on CD
- ☐ After Allowance Communication to TC
- ☐ Appeal Communication to Board of Appeals and Interferences
- ☐ Appeal Communication to TC **(Appeal Notice, Brief, Reply Brief)**
- ☐ Proprietary Information
- ☐ Status Letter
- ☒ Other Enclosure(s) (please Identify below):

PTO - 1449 with one (1) cited reference

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	VOLPE AND KOENIG, P.C.		
Signature	Scott Wolinsky		
Printed name	Scott Wolinsky		
Date	February 11, 2009	Reg. No.	46,413

CERTIFICATE OF TRANSMISSION/MAILING

I hereby certify that this correspondence is being facsimile transmitted to the USPTO or deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Mail Stop Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date shown below:

Signature	Scott Wolinsky		
Typed or printed name	Scott Wolinsky	Date	February 11, 2009

This collection of information is required by 37 CFR 1.5. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and1.14. This collection is estimated to 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the PATENT APPLICATION of:	
	Pietraski et al.
Application No.:	11/974,381
Confirmation No.:	4314
Filed:	October 12, 2007
For: DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	
Group:	2112
Examiner:	Not Yet Known

Our File:	I-2-0526.2US
Date:	February 11, 2009

INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Examiner:

Further to Applicants' Duty of Disclosure pursuant to 37 C.F.R. §1.56, Applicants wish to bring to the Examiner's attention the material cited on the enclosed Form PTO-1449.

The listed references include references previously cited in this application. Newly cited documents are indicated by an asterisk (*) on the enclosed Form PTO-1449. Copies of the newly cited documents are enclosed.

It is respectfully requested that the Examiner consider these documents and return an initialed copy of the Form PTO-1449 indicating consideration of the cited materials.

Respectfully submitted,

Pietraski et al.

By Scott Wolinsky
Scott Wolinsky
Registration No. 46,413
(215) 568-6400

Volpe and Koenig, P.C.
United Plaza, Suite 1600
30 South 17th Street
Philadelphia, PA 19103

SW/pck
Enclosures (2)

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the **PATENT APPLICATION** of:	
Pietraski et al.	
Application No.: 11/974,381	
Confirmation No.: 4314	
Filed: October 12, 2007	Our File: I-2-0526.2US
For: DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	Date: January 16, 2009
Group: 2112	
Examiner: Not Yet Known	

PRELIMINARY AMENDMENT

Mail Stop Amendment
Commissioner for Patents
Post Office Box 1450
Alexandria, Virginia 22313-1450

Sir:

Applicants respectfully request that the above-captioned application be amended prior to the initial office action as follows.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claims 1-9 (canceled)

10. (new): A method of rate matching comprising:

interleaving systematic bits;

interleaving a first parity bit stream;

interleaving a second parity bit stream;

buffering the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream in a virtual buffer when the number of bits of the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream is not larger than the virtual buffer;

buffering a portion of the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream when the number of bits of the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream is larger than the virtual buffer; and

using a rate-matching unit to perform rate matching on at least one output of the virtual buffer.

11. (new): The method of claim 10 wherein the buffered portion includes all of the interleaved systematic bits.

12. (new): The method of claim 10 further comprising:

collecting bits associated with the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream.

13. (new): A wireless transmit/receive unit (WTRU) comprising:

a first interleaver configured to interleave systematic bits;

a second interleaver configured to interleave a first parity bit stream;

a third interleaver configured to interleave a second parity bit stream;

a virtual buffer configured to buffer the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream when the number of bits of the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream is not larger than the virtual buffer and configured to buffer a portion of the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream when the number of bits of the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream is larger than the virtual buffer; and

a rate matching unit configured to perform rate matching on at least one output of the virtual buffer.

14. (new): The WTRU of claim 13 wherein the buffered portion includes all of the interleaved systematic bits.

15. (new): The WTRU of claim 13 further comprising:

a bit collection unit configured to collect bits associated with the interleaved systematic bits, the interleaved first parity bit stream and the interleaved second parity bit stream.

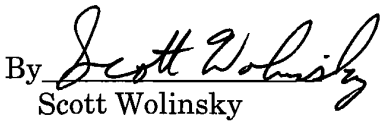
REMARKS/COMMENTS

Pursuant to this Preliminary Amendment, claims 1-9 have been canceled and new claims 10-15 have been added.

Consideration and entry of this Preliminary Amendment is respectively requested.

Respectfully submitted,

Pietraski et al.

By 
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Registration No. 46,413

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SW/bbf/yil

Electronic Acknowledgement Receipt	
EFS ID:	4625761
Application Number:	11974381
International Application Number:	
Confirmation Number:	4314
Title of Invention:	Detection, avoidance and/or correction of problematic puncturing patterns in parity bit streams used when implementing turbo codes
First Named Inventor/Applicant Name:	Philip J. Pietraski
Customer Number:	24374
Filer:	Thomas A Mattioli/Yolanda Lopez
Filer Authorized By:	Thomas A Mattioli
Attorney Docket Number:	I-2-0526.2US
Receipt Date:	16-JAN-2009
Filing Date:	12-OCT-2007
Time Stamp:	10:45:14
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Preliminary Amendment	20090116_I_2_0526_2US_PreliminaryAmendment.pdf	26163 b64486b8adbef04361c5adace69d6a5284aaade0	no	4
Warnings:					
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APPLICATION NUMBER	FILING OR 371(c) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/974,381	10/12/2007	Philip J. Pietraski	I-2-0526.2US

CONFIRMATION NO. 4314

24374
VOLPE AND KOENIG, P.C.
DEPT. ICC
UNITED PLAZA, SUITE 1600
30 SOUTH 17TH STREET
PHILADELPHIA, PA19103

Title: Detection, avoidance and/or correction of problematic puncturing patterns in parity bit streams used when implementing turbo codes

Publication No. US-2008-0046800-A1
Publication Date: 02/21/2008

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

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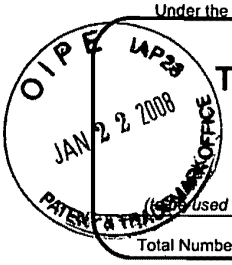
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TRANSMITTAL FORM

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Total Number of Pages in This Submission

Application Number	11/974,381
Filing Date	October 12, 2007
First Named Inventor	Pietraski et al.
Art Unit	2112
Examiner Name	Not Yet Known
Attorney Docket Number	I-2-0526.2US

ENCLOSURES *(Check all that apply)*

- ☐ Fee Transmittal Form
  - ☐ Fee Attached
- ☐ Amendment/Reply
  - ☐ After Final
  - ☐ Affidavits/declaration(s)
- ☐ Extension of Time Request
- ☐ Express Abandonment Request
- ☒ Information Disclosure Statement
- ☐ Certified Copy of Priority Document(s)
- ☐ Reply to Missing Parts/ Incomplete Application
  - ☐ Reply to Missing Parts under 37 CFR 1.52 or 1.53
- ☐ Drawing(s)
- ☐ Licensing-related Papers
- ☐ Petition
- ☐ Petition to Convert to a Provisional Application
- ☐ Power of Attorney, Revocation Change of Correspondence Address
- ☐ Terminal Disclaimer
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- ☐ CD, Number of CD(s) _____
  - ☐ Landscape Table on CD
- ☐ After Allowance Communication to TC
- ☐ Appeal Communication to Board of Appeals and Interferences
- ☐ Appeal Communication to TC **(Appeal Notice, Brief, Reply Brief)**
- ☐ Proprietary Information
- ☐ Status Letter
- ☒ Other Enclosure(s) (please Identify below):

PTO - 1449 With Twenty-One (21) References.

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	VOLPE AND KOENIG, P.C.		
Signature			
Printed name	Gerald B. Halt, Jr.		
Date	January 17, 2008	Reg. No.	37,633

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Signature			
Typed or printed name	Gerald B. Halt, Jr.	Date	January 17, 2008

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the PATENT APPLICATION of:	Pietraski et al.
Application No.:	11/974,381
Confirmation No.:	4314
Filed:	October 12, 2007
For:	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES
Group:	2112
Examiner:	Not Yet Known

Our File: I-2-0526.2US

Date: January 17, 2008

INFORMATION DISCLOSURE STATEMENT

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Sir:

Further to Applicants' Duty of Disclosure pursuant to 37 C.F.R. §1.56, Applicants wish to bring to the Examiner's attention the material cited on the enclosed Form PTO-1449.

This application is a continuation of Application No. 10/725,779, filed on December 12, 2003, which issued on November 6, 2007 as U.S. Patent No. 7,293,217, which claims priority benefit from U.S. Provisional Patent Applications Serial No. 60/434,232, filed on December 16, 2002, Serial No. 60/444,068, filed on January 30,

2003, Serial No. 60/470,921, filed on May 15, 2003 and Serial No. 60/494,404, filed on August 11, 2003. Further to Applicants' Duty of Disclosure pursuant to 37 C.F.R. §1.56, Applicants wish to bring to the Examiner's attention the material cited on the enclosed Form PTO-1449. Pursuant to 37 C.F.R. §1.98(d) copies of documents cited in the parent application are not enclosed, but copies will be provided upon request. Newly cited documents are identified on the enclosed Form PTO-1449 form by an asterisk (*).

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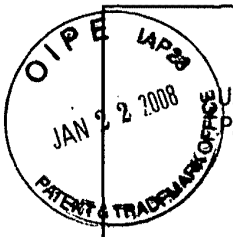
Respectfully submitted,

Pietraski et al.

By_____
Gerald B. Halt, Jr.
Registration No. 37,633
(215) 568-6400

Volpe and Koenig, P.C.
United Plaza, Suite 1600
30 South 17th Street
Philadelphia, PA 19103

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Enclosures (21)



FORM PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use several sheets if necessary)	ATTY. DOCKET NO. I-2-0526.2US	SERIAL NO. 11/974,381
	APPLICANT Pietraski et al.	
	FILING DATE October 12, 2007	GROUP 2112

U.S. PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
		6,370,669	04/2002	Eroz et al.			
		6,601,214	07/2003	Hammons, Jr.			
		6,622,281	09/2003	Yun et al.			
		6,665,813	12/2003	Forsman et al.			
		7,076,726	07/2006	Yun et al.			
		2002/0027956	03/2002	Lee et al.			
		2002/0141433	10/2002	Kwon et al.			
		2003/0007476	01/2003	Kim et al.			

FOREIGN PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
		00/11791	03/2000	WO			X[1]	
		00/41343	07/2000	WO			X[2]	
		02/33910	04/2002	WO			X[3]	
		03/069784	08/2003	WO			X[4]	

OTHER DOCUMENTS

EXAMINER INITIAL		DESCRIPTION (Including Author, Title, Date, Pertinent Pages, Etc.)
	*	INTERDIGITAL, "Turbo-Coding And Pubcturing Interactions On HS-DSCH In R5 HSDPA", TSG-RAN Working Group 1 Meeting #32, R1-030444, (Paris, France 19-23 May 2003).
		Mo et al., "Analysis of Puncturing Pattern for High Rate Turbo Codes," IEEE International, 0-7803-5538-5/99, 1999, pgs. 547-550.

EXAMINER	DATE CONSIDERED

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	APPLICANT Pietraski et al.	
	FILING DATE October 12, 2007	GROUP 2112

EXAMINER INITIAL		DESCRIPTION (Including Author, Title, Date, Pertinent Pages, Etc.)
	*	SIEMENS ET AL., "HSDPA For The 1,28 Mcps TDD Option – A-VRC Test Methodology And Simulation Assumptions", TSG-RAN Working Group 4 (Radio) Meeting #26, R4-030223, (Madrid, Spain 17-21 February 2003).
	*	SIEMENS, "Turbo Coder Irregularities In HSDPA", 3GPP TSG-RAN Working Group 1 #32, Toc R1-030421, (Paris, France 19-23 May 2003).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (FDD) (Release 6)", 3GPP TS 25.212 V6.1.0 (March 2004).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 6)", 3GPP TS 25.222 V6.0.0 (December 2003).
		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Channel Coding And Multiplexing Examples (Release 4)", 3GPP TS 25.944 V4.1.0 (June 2001).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) Protocol Specification (Release 5)", 3GPP TS 25.321 V5.6.0 (September 2003).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; MAC Protocol Specification (Release 5)", 3GPP TS 25.321 V5.2.0 (September 2002).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) Protocol Specification (Release 4)", 3GPP TS 25.321 V4.9.0 (September 2003).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; MAC Protocol Specification (Release 4)", 3GPP TS 25.321 V4.6.0 (September 2002).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Medium Access Control (MAC) Protocol Specification (Release 1999)", 3GPP TS 25.321 V3.16.0 (September 2003).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; MAC Protocol Specification (Release 1999)", 3GPP TS 25.321 V3.13.0 (September 2002).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Channel Coding And Multiplexing Samples (Release 1999)", 3GPP TR 25.944 V3.5.0 (June 2001).

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	APPLICANT Pietraski et al.	
	FILING DATE October 12, 2007	GROUP 2112

EXAMINER INITIAL		DESCRIPTION (Including Author, Title, Date, Pertinent Pages, Etc.)
	*	THIRD GENERATION PARTNERSHIP PROJECT; "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (FDD) (Release 5)", 3GPP TS 25.212 V5.2.0 (September 2002).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (FDD) (Release 5)", 3GPP TS 25.212 V5.4.0 (March 2003).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (FDD) (Release 5)", 3GPP TS 25.212 V5.6.0 (September 2003).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.7.0 (September 2004).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 1999)", 3GPP TS 25.222 V3.8.0 (March 2002).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 1999)", 3GPP TS 25.222 V3.10.0 (September 2002).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 4)", 3GPP TS 25.222 V4.5.0 (September 2002).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 4)", 3GPP TS 25.222 V4.6.0 (December 2002).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.2.1 (October 2002).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.4.0 (March 2003).
	*	THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; Multiplexing And Channel Coding (TDD) (Release 5)", 3GPP TS 25.222 V5.5.0 (June 2003).

X[1] Equivalent to RU 2190296

X[2] Equivalent to RU 2185025

X[3] Equivalent to RU 2239292

X[4] Equivalent to RU 2004127246

EXAMINER	DATE CONSIDERED

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3GPP TS 25.222 V5.7.0 (2004-09)

Technical Specification

3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Multiplexing and channel coding (TDD) (Release 5)



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Keywords
UMTS, radio, mux

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Foreword

This Technical Specification (TS) has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

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1 Scope

The present document describes multiplexing, channel coding and interleaving for UTRA Physical Layer TDD mode.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document.*

[1] 3GPP TS 25.202: "UE capabilities".

[2] 3GPP TS 25.211: "Transport channels and physical channels (FDD)".

[3] 3GPP TS 25.212: "Multiplexing and channel coding (FDD)".

[4] 3GPP TS 25.213: "Spreading and modulation (FDD)".

[5] 3GPP TS 25.214: "Physical layer procedures (FDD)".

[6] 3GPP TS 25.215: "Physical layer – Measurements (FDD)".

[7] 3GPP TS 25.221: "Transport channels and physical channels (TDD)".

[9] 3GPP TS 25.223: "Spreading and modulation (TDD)".

[10] 3GPP TS 25.224: "Physical layer procedures (TDD)".

[11] 3GPP TS 25.225: "Measurements".

[12] 3GPP TS 25.331: "RRC Protocol Specification".

[13] 3GPP TS 25.308: "High Speed Downlink Packet Access (HSDPA): Overall description (stage 2)".

[14] ITU-T Recommendation X.691 (12/97) "Information technology - ASN.1 encoding rules: Specification of Packed Encoding Rules (PER)".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply.

TrCH number: The transport channel number identifies a TrCH in the context of L1. The L3 transport channel identity (TrCH ID) maps onto the L1 transport channel number. The mapping between the transport channel number and the TrCH ID is as follows: TrCH 1 corresponds to the TrCH with the lowest TrCH ID, TrCH 2 corresponds to the TrCH with the next lowest TrCH ID and so on.

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3.2 Symbols

For the purposes of the present document, the following symbols apply:

$\lceil x \rceil$	round towards ∞, i.e. integer such that $x \leq \lceil x \rceil < x+1$
$\lfloor x \rfloor$	round towards $-\infty$, i.e. integer such that $x-1 < \lfloor x \rfloor \leq x$
$\lvert x \rvert$	absolute value of x

Unless otherwise is explicitly stated when the symbol is used, the meaning of the following symbols are:

i	TrCH number
j	TFC number
k	Bit number
l	TF number
m	Transport block number
n	Radio frame number
p	PhCH number
r	Code block number
I	Number of TrCHs in a CCTrCH.
C_i	Number of code blocks in one TTI of TrCH i.
F_i	Number of radio frames in one TTI of TrCH i.
M_i	Number of transport blocks in one TTI of TrCH i.
$N_{TCFI\ code\ word}$	Number of TFCI code word bits after TFCI encoding
P	Number of PhCHs used for one CCTrCH.
PL	Puncturing Limit. Signalled from higher layers
RM_i	Rate Matching attribute for TrCH i. Signalled from higher layers.

Temporary variables, i.e. variables used in several (sub)clauses with different meaning.

x, X
y, Y
z, Z

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

<ACRONYM>	<Explanation>
ARQ	Automatic Repeat on Request
BCH	Broadcast Channel
BER	Bit Error Rate
BS	Base Station
BSS	Base Station Subsystem
CBR	Constant Bit Rate
CCCH	Common Control Channel
CCTrCH	Coded Composite Transport Channel
CDMA	Code Division Multiple Access
CFN	Connection Frame Number
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
DCA	Dynamic Channel Allocation
DCCH	Dedicated Control Channel
DCH	Dedicated Channel
DL	Downlink
DRX	Discontinuous Reception
DSCH	Downlink Shared Channel
DTX	Discontinuous Transmission
FACH	Forward Access Channel
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
FEC	Forward Error Control

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FER	Frame Error Rate
GF	Galois Field
HARQ	Hybrid Automatic Repeat reQuest
HS-DSCH	High Speed Downlink Shared Channel
HS-PDSCH	High Speed Physical Downlink Shared Channel
HS-SCCH	Shared Control Channel for HS-DSCH
HS-SICH	Shared Information Channel for HS-DSCH
JD	Joint Detection
L1	Layer 1
L2	Layer 2
LLC	Logical Link Control
MA	Multiple Access
MAC	Medium Access Control
MS	Mobile Station
MT	Mobile Terminated
NRT	Non-Real Time
OVSF	Orthogonal Variable Spreading Factor
PC	Power Control
PCCC	Parallel Concatenated Convolutional Code
PCH	Paging Channel
PhCH	Physical Channel
PI	Paging Indicator (value calculated by higher layers)
P_q	Paging Indicator (indicator set by physical layer)
QoS	Quality of Service
QPSK	Quaternary Phase Shift Keying
RACH	Random Access Channel
RF	Radio Frequency
RLC	Radio Link Control
RMF	Recommended Modulation Format
RRC	Radio Resource Control
RRM	Radio Resource Management
RSC	Recursive Systematic Convolutional Coder
RT	Real Time
RTBS	Recommended Transport Block Size
RU	Resource Unit
RV	Redundancy Version
SCCC	Serial Concatenated Convolutional Code
SCH	Synchronization Channel
SNR	Signal to Noise Ratio
TCH	Traffic channel
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TFC	Transport Format Combination
TFCI	Transport Format Combination Indicator
TFRI	Transport Format Resouce Indicator
TPC	Transmit Power Control
TrBk	Transport Block
TrCH	Transport Channel
TTI	Transmission Time Interval
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System
USCH	Uplink Shared Channel
UTRA	UMTS Terrestrial Radio Access
VBR	Variable Bit Rate

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4 Multiplexing, channel coding and interleaving

4.1 General

Data stream from/to MAC and higher layers (Transport block / Transport block set) is encoded/decoded to offer transport services over the radio transmission link. Channel coding scheme is a combination of error detection, error correcting (including rate matching), and interleaving and transport channels mapping onto/splitting from physical channels.

In the UTRA-TDD mode, the total number of basic physical channels (a certain time slot one spreading code on a certain carrier frequency) per frame is given by the maximum number of time slots and the maximum number of CDMA codes per time slot.

4.2 General coding/multiplexing of TrCHs

This section only applies to the transport channels: DCH, RACH, DSCH, USCH, BCH, FACH and PCH. Other transport channels which do not use the general method are described separately below.

Figure 1 illustrates the overall concept of transport-channel coding and multiplexing. Data arrives to the coding/multiplexing unit in form of transport block sets, once every transmission time interval. The transmission time interval is transport-channel specific from the set {5 ms(*1), 10 ms, 20 ms, 40 ms, 80 ms}.

Note: (*1) may be applied for PRACH for 1.28 Mcps TDD

The following coding/multiplexing steps can be identified:

- add CRC to each transport block (see subclause 4.2.1);
- TrBk concatenation / Code block segmentation (see subclause 4.2.2);
- channel coding (see subclause 4.2.3) ;
- radio frame size equalization (see subclause 4.2.4);
- interleaving (two steps, see subclauses 4.2.5 and 4.2.11);
- radio frame segmentation (see subclause 4.2.6);
- rate matching (see subclause 4.2.7);
- multiplexing of transport channels (see subclause 4.2.8);
- bit scrambling (see subclause 4.2.9);
- physical channel segmentation (see subclause 4.2.10);
- sub-frame segmentation(see subclause 4.2.11A only for 1.28Mcps TDD)
- mapping to physical channels (see subclause 4.2.12).

The coding/multiplexing steps for uplink and downlink are shown in figures 1 and 1A.

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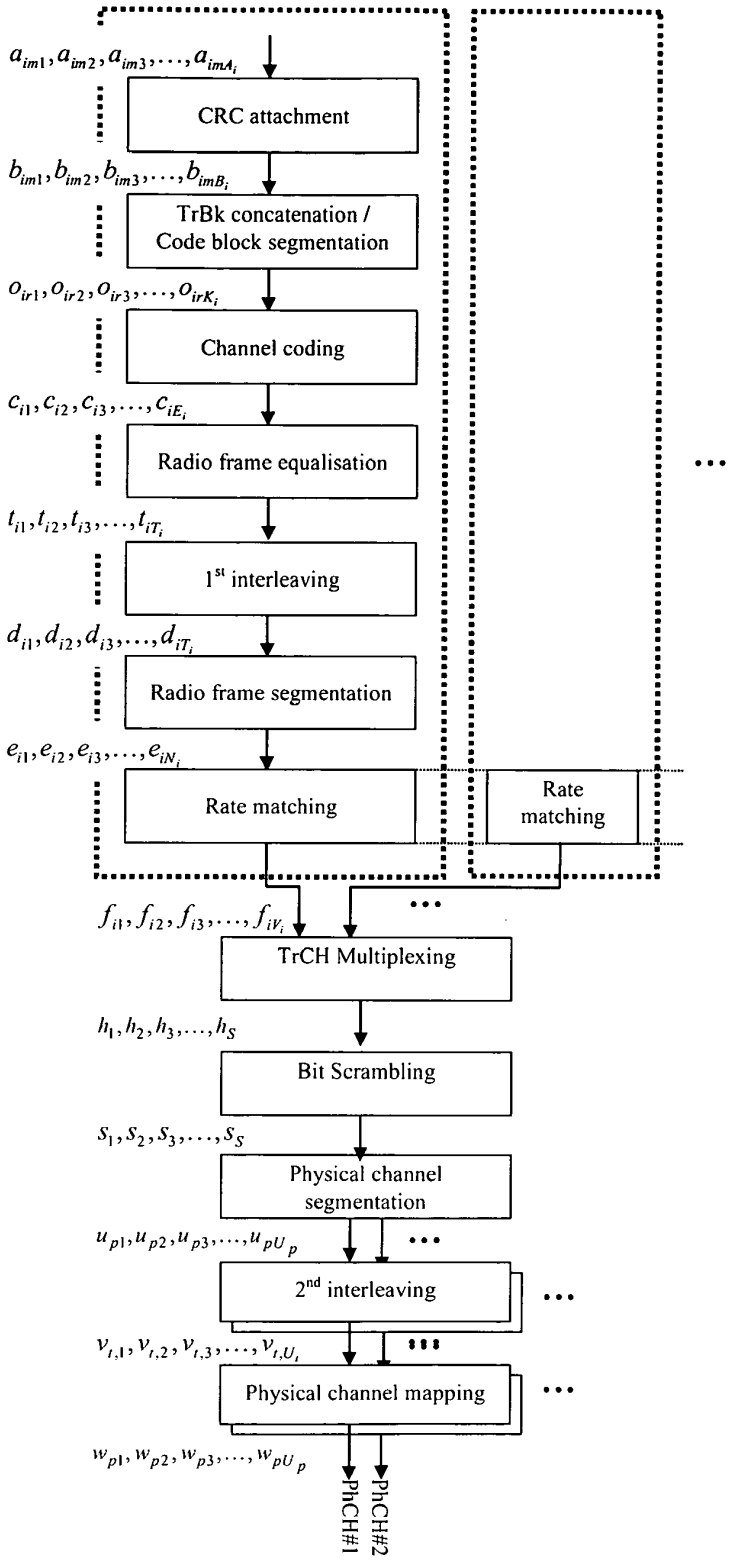


Figure 1: Transport channel multiplexing structure for uplink and downlink for 3.84Mcps TDD

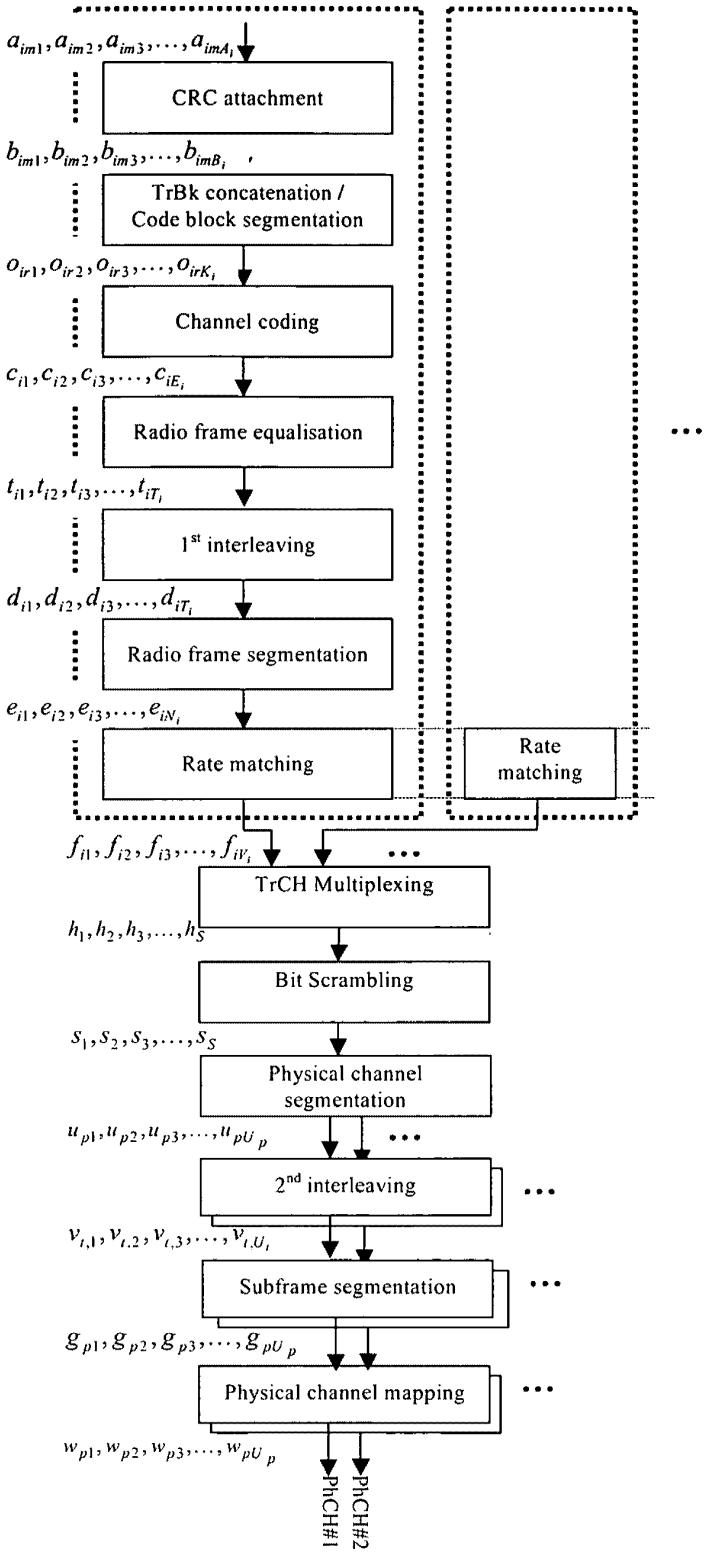


Figure 1A: Transport channel multiplexing structure for uplink and downlink of 1.28Mcps TDD

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Primarily, transport channels are multiplexed as described above, i.e. into one data stream mapped on one or several physical channels. However, an alternative way of multiplexing services is to use multiple CCTrCHs (Coded Composite Transport Channels), which corresponds to having several parallel multiplexing chains as in figures 1 and 1A, resulting in several data streams, each mapped to one or several physical channels.

4.2.1 CRC attachment

Error detection is provided on transport blocks through a Cyclic Redundancy Check (CRC). The size of the CRC is 24, 16, 12, 8 or 0 bits and it is signalled from higher layers what CRC size that should be used for each transport channel.

4.2.1.1 CRC calculation

The entire transport block is used to calculate the CRC parity bits for each transport block. The parity bits are generated by one of the following cyclic generator polynomials:

$g_{CRC24}(D) = D^{24} + D^{23} + D^6 + D^5 + D + 1$

$g_{CRC16}(D) = D^{16} + D^{12} + D^5 + 1$

$g_{CRC12}(D) = D^{12} + D^{11} + D^3 + D^2 + D + 1$

$g_{CRC8}(D) = D^8 + D^7 + D^4 + D^3 + D + 1$

Denote the bits in a transport block delivered to layer 1 by $a_{im1}, a_{im2}, a_{im3}, \ldots, a_{imA_i}$, and the parity bits by $p_{im1}, p_{im2}, p_{im3}, \ldots, p_{imL_i}$. A_i is the size of a transport block of TrCH *i*, *m* is the transport block number, and L_i is the number of parity bits. L_i can take the values 24, 16, 12, 8, or 0 depending on what is signalled from higher layers.

The encoding is performed in a systematic form, which means that in GF(2), the polynomial:

$$a_{im1}D^{A_i+23} + a_{im2}D^{A_i+22} + \ldots + a_{imA_i}D^{24} + p_{im1}D^{23} + p_{im2}D^{22} + \ldots + p_{im23}D^1 + p_{im24}$$

yields a remainder equal to 0 when divided by $g_{CRC24}(D)$, polynomial:

$$a_{im1}D^{A_i+15} + a_{im2}D^{A_i+14} + \ldots + a_{imA_i}D^{16} + p_{im1}D^{15} + p_{im2}D^{14} + \ldots + p_{im15}D^1 + p_{im16}$$

yields a remainder equal to 0 when divided by $g_{CRC16}(D)$, polynomial:

$$a_{im1}D^{A_i+11} + a_{im2}D^{A_i+10} + \ldots + a_{imA_i}D^{12} + p_{im1}D^{11} + p_{im2}D^{10} + \ldots + p_{im11}D^1 + p_{im12}$$

yields a remainder equal to 0 when divided by $g_{CRC12}(D)$ and the polynomial:

$$a_{im1}D^{A_i+7} + a_{im2}D^{A_i+6} + \ldots + a_{imA_i}D^8 + p_{im1}D^7 + p_{im2}D^6 + \ldots + p_{im7}D^1 + p_{im8}$$

yields a remainder equal to 0 when divided by $g_{CRC8}(D)$.

If no transport blocks are input to the CRC calculation ($M_i = 0$), no CRC attachment shall be done. If transport blocks are input to the CRC calculation ($M_i \neq 0$) and the size of a transport block is zero ($A_i = 0$), CRC shall be attached, i.e. all parity bits equal to zero.

4.2.1.2 Relation between input and output of the CRC attachment block

The bits after CRC attachment are denoted by $b_{im1}, b_{im2}, b_{im3}, \ldots, b_{imB_i}$, where $B_i = A_i + L_i$. The relation between a_{imk} and b_{imk} is:

$b_{imk} = a_{imk}$ $\quad k = 1, 2, 3, \ldots, A_i$

$b_{imk} = p_{im(L_i+1-(k-A_i))}$ $\quad k = A_i + 1, A_i + 2, A_i + 3, \ldots, A_i + L_i$

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4.2.2 Transport block concatenation and code block segmentation

All transport blocks in a TTI are serially concatenated. If the number of bits in a TTI is larger than the maximum size of a code block, then code block segmentation is performed after the concatenation of the transport blocks. The maximum size of the code blocks depends on whether convolutional, turbo coding or no coding is used for the TrCH.

4.2.2.1 Concatenation of transport blocks

The bits input to the transport block concatenation are denoted by $b_{im1}, b_{im2}, b_{im3}, \ldots, b_{imB_i}$ where i is the TrCH number, m is the transport block number, and B_i is the number of bits in each block (including CRC). The number of transport blocks on TrCH i is denoted by M_i. The bits after concatenation are denoted by $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$, where i is the TrCH number and $X_i=M_iB_i$. They are defined by the following relations:

$x_{ik} = b_{i1k}$ $k = 1, 2, \ldots, B_i$

$x_{ik} = b_{i,2,(k-B_i)}$ $k = B_i + 1, B_i + 2, \ldots, 2B_i$

$x_{ik} = b_{i,3,(k-2B_i)}$ $k = 2B_i + 1, 2B_i + 2, \ldots, 3B_i$

...

$x_{ik} = b_{i,M_i,(k-(M_i-1)B_i)}$ $k = (M_i - 1)B_i + 1, (M_i - 1)B_i + 2, \ldots, M_iB_i$

4.2.2.2 Code block segmentation

Segmentation of the bit sequence from transport block concatenation is performed if $X_i>Z$. The code blocks after segmentation are of the same size. The number of code blocks on TrCH i is denoted by C_i. If the number of bits input to the segmentation, X_i, is not a multiple of C_i, filler bits are added to the beginning of the first block. If turbo coding is selected and $X_i < 40$, filler bits are added to the beginning of the code block. The filler bits are transmitted and they are always set to 0. The maximum code block sizes are:

- convolutional coding: $Z = 504$;
- turbo coding: $Z = 5114$;
- no channel coding: $Z = unlimited$.

The bits output from code block segmentation, for $C_i \neq 0$, are denoted by $o_{ir1}, o_{ir2}, o_{ir3}, \ldots, o_{irK_i}$, where i is the TrCH number, r is the code block number, and K_i is the number of bits per code block.

Number of code blocks:

$$C_i = \begin{cases} \lceil X_i / Z \rceil & \text{when } Z \neq unlimited \\ 0 & \text{when } Z = unlimited \text{ and } X_i = 0 \\ 1 & \text{when } Z = unlimited \text{ and } X_i \neq 0 \end{cases}$$

Number of bits in each code block (applicable for $C_i \neq 0$ only):

if $X_i < 40$ and Turbo coding is used, then

$K_i = 40$

else

$K_i = \lceil X_i / C_i \rceil$

end if

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Number of filler bits: $Y_i = C_i K_i - X_i$

for $k = 1$ to Y_i -- Insertion of filler bits

$o_{i1k} = 0$

end for

for $k = Y_i + 1$ to K_i

$o_{i1k} = x_{i,(k-Y_i)}$

end for

$r = 2$ -- Segmentation

while $r \leq C_i$

for $k = 1$ to K_i

$o_{irk} = x_{i,(k+(r-1)\cdot K_i - Y_i)}$

end for

r = r+1

end while

4.2.3 Channel coding

Code blocks are delivered to the channel coding block. They are denoted by $o_{ir1}, o_{ir2}, o_{ir3}, \ldots, o_{irK_i}$, where i is the TrCH number, r is the code block number, and K_i is the number of bits in each code block. The number of code blocks on TrCH i is denoted by C_i. After encoding the bits are denoted by $y_{ir1}, y_{ir2}, y_{ir3}, \ldots, y_{irY_i}$, where Y_i is the number of encoded bits. The relation between o_{irk} and y_{irk} and between K_i and Y_i is dependent on the channel coding scheme.

The following channel coding schemes can be applied to transport channels:

- convolutional coding;
- turbo coding;
- no coding.

Usage of coding scheme and coding rate for the different types of TrCH is shown in tables 1 and 1A. The values of Y_i in connection with each coding scheme:

- convolutional coding with rate 1/2: $Y_i = 2*K_i + 16$; rate 1/3: $Y_i = 3*K_i + 24$;
- turbo coding with rate 1/3: $Y_i = 3*K_i + 12$;
- no coding: $Y_i = K_i$.

Table 1: Usage of channel coding scheme and coding rate for 3.84Mcps TDD

Type of TrCH	Coding scheme	Coding rate
BCH	Convolutional coding	1/2
PCH		
RACH		
DCH, DSCH, FACH, USCH		1/3, 1/2
	Turbo coding	1/3
	No coding	

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Table 1A: Usage of channel coding scheme and coding rate for 1.28Mcps TDD

Type of TrCH	Coding scheme	Coding rate
BCH	Convolutional coding	1/3
PCH		1/3, 1/2
RACH		1/2
DCH, DSCH, FACH, USCH		1/3, 1/2
	Turbo coding	1/3
	No coding	

4.2.3.1 Convolutional coding

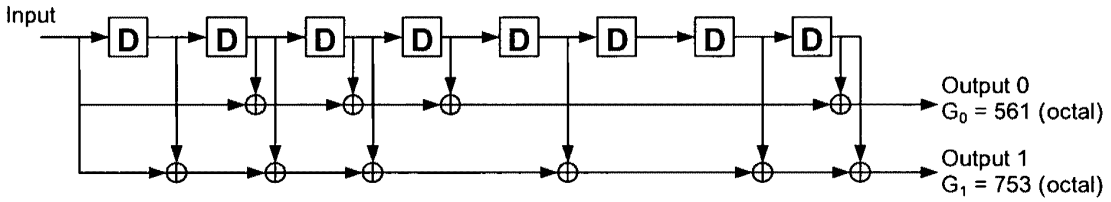
Convolutional codes with constraint length 9 and coding rates 1/3 and 1/2 are defined.

The configuration of the convolutional coder is presented in figure 2.

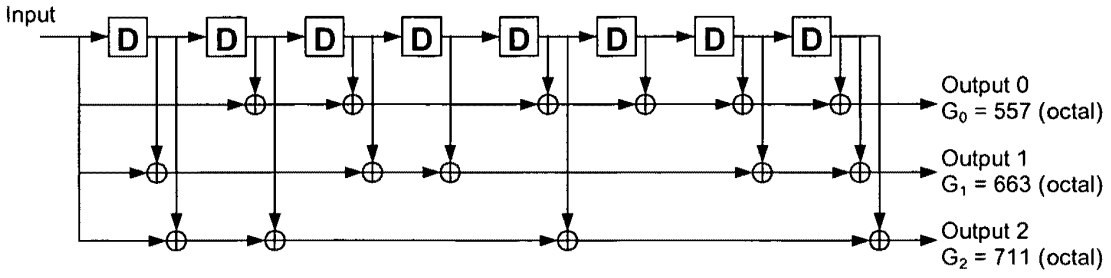
Output from the rate 1/3 convolutional coder shall be done in the order output 0, output 1, output 2, output 0, output 1, output 2, output 0,...,output 2. Output from the rate 1/2 convolutional coder shall be done in the order output 0, output 1, output 0, output 1, output 0, ..., output 1.

8 tail bits with binary value 0 shall be added to the end of the code block before encoding.

The initial value of the shift register of the coder shall be "all 0" when starting to encode the input bits.



(a) Rate 1/2 convolutional coder



(b) Rate 1/3 convolutional coder

Figure 2: Rate 1/2 and rate 1/3 convolutional coders

4.2.3.2 Turbo coding

4.2.3.2.1 Turbo coder

The scheme of Turbo coder is a Parallel Concatenated Convolutional Code (PCCC) with two 8-state constituent encoders and one Turbo code internal interleaver. The coding rate of Turbo coder is 1/3. The structure of Turbo coder is illustrated in figure 3.

The transfer function of the 8-state constituent code for PCCC is:

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$$G(D)= \left[1, \frac{g_1(D)}{g_0(D)}\right],$$

where

$$g_0(D) = 1 + D^2 + D^3,$$

$$g_1(D) = 1 + D + D^3.$$

The initial value of the shift registers of the 8-state constituent encoders shall be all zeros when starting to encode the input bits.

Output from the Turbo coder is , Y'(0), X(1), Y(1), Y'(1), etc:

$$x_1, z_1, z'_1, x_2, z_2, z'_2, \ldots, x_K, z_K, z'_K,$$

where $x_1, x_2, \ldots, x_K$ are the bits input to the Turbo coder i.e. both first 8-state constituent encoder and Turbo code internal interleaver, and K is the number of bits, and $z_1, z_2, \ldots, z_K$ and $z'_1, z'_2, \ldots, z'_K$ are the bits output from first and second 8-state constituent encoders, respectively.

The bits output from Turbo code internal interleaver are denoted by $x'_1, x'_2, \ldots, x'_K$, and these bits are to be input to the second 8-state constituent encoder.

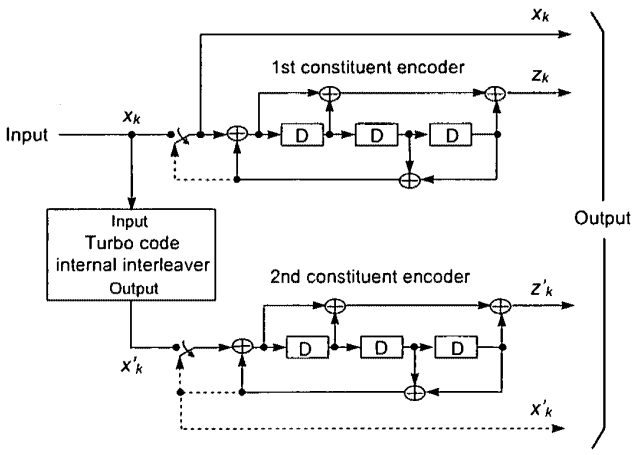


Figure 3: Structure of rate 1/3 Turbo coder (dotted lines apply for trellis termination only)

4.2.3.2.2 Trellis termination for Turbo coder

Trellis termination is performed by taking the tail bits from the shift register feedback after all information bits are encoded. Tail bits are padded after the encoding of information bits.

The first three tail bits shall be used to terminate the first constituent encoder (upper switch of figure 3 in lower position) while the second constituent encoder is disabled. The last three tail bits shall be used to terminate the second constituent encoder (lower switch of figure 3 in lower position) while the first constituent encoder is disabled.

The transmitted bits for trellis termination shall then be:

$$x_{K+1}, z_{K+1}, x_{K+2}, z_{K+2}, x_{K+3}, z_{K+3}, x'_{K+1}, z'_{K+1}, x'_{K+2}, z'_{K+2}, x'_{K+3}, z'_{K+3}.$$

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4.2.3.2.3 Turbo code internal interleaver

The Turbo code internal interleaver consists of bits-input to a rectangular matrix with padding, intra-row and inter-row permutations of the rectangular matrix, and bits-output from the rectangular matrix with pruning. The bits input to the Turbo code internal interleaver are denoted by $x_1, x_2, x_3, \ldots, x_K$, where K is the integer number of the bits and takes one value of $40 \leq K \leq 5114$. The relation between the bits input to the Turbo code internal interleaver and the bits input to the channel coding is defined by $x_k = o_{irk}$ and $K = K_i$.

The following subclause specific symbols are used in subclauses 4.2.3.2.3.1 to 4.2.3.2.3.3 :

K	Number of bits input to Turbo code internal interleaver
R	Number of rows of rectangular matrix
C	Number of columns of rectangular matrix
p	Prime number
v	Primitive root
$\langle s(j) \rangle_{j \in \{0,1,\cdots,p-2\}}$	Base sequence for intra-row permutation
q_i	Minimum prime integers
r_i	Permuted prime integers
$\langle T(i) \rangle_{i \in \{0,1,\cdots,R-1\}}$	Inter-row permutation pattern
$\langle U_i(j) \rangle_{j \in \{0,1,\cdots,C-1\}}$	Intra-row permutation pattern of i-th row
i	Index of row number of rectangular matrix
j	Index of column number of rectangular matrix
k	Index of bit sequence

4.2.3.2.3.1 Bits-input to rectangular matrix with padding

The bit sequence $x_1, x_2, x_3, \ldots, x_K$ input to the Turbo code internal interleaver is written into the rectangular matrix as follows.

(1) Determine the number of rows of the rectangular matrix, R, such that:

$$R = \begin{cases} 5, \text{if } (40 \leq K \leq 159) \\ 10, \text{if } ((160 \leq K \leq 200) \text{ or } (481 \leq K \leq 530)) \\ 20, \text{if } (K = \text{any other value}) \end{cases}.$$

The rows of rectangular matrix are numbered 0, 1, ..., R - 1 from top to bottom.

(2) Determine the prime number to be used in the intra-permutation, p, and the number of columns of rectangular matrix, C, such that:

if $(481 \leq K \leq 530)$ then

$p = 53$ and $C = p$.

else

Find minimum prime number p from table 2 such that

$$K \leq R \times (p+1),$$

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and determine C such that

$$C = \begin{cases} p-1 & if \quad K \le R \times (p-1) \\ p & if \quad R \times (p-1) < K \le R \times p \\ p+1 & if \quad R \times p < K \end{cases}.$$

end if

The columns of rectangular matrix are numbered 0, 1, ..., C - 1 from left to right.

Table 2: List of prime number *p* and associated primitive root *v*

p	v	p	v	p	v	p	v	p	v
7	3	47	5	101	2	157	5	223	3
11	2	53	2	103	5	163	2	227	2
13	2	59	2	107	2	167	5	229	6
17	3	61	2	109	6	173	2	233	3
19	2	67	2	113	3	179	2	239	7
23	5	71	7	127	3	181	2	241	7
29	2	73	5	131	2	191	19	251	6
31	3	79	3	137	3	193	5	257	3
37	2	83	2	139	2	197	2		
41	6	89	3	149	2	199	3		
43	3	97	5	151	6	211	2		

(3) Write the input bit sequence $x_1, x_2, x_3, \ldots, x_K$ into the $R \times C$ rectangular matrix row by row starting with bit y_1 in column 0 of row 0:

$$\begin{bmatrix} y_1 & y_2 & y_3 & \cdots & y_C \\ y_{(C+1)} & y_{(C+2)} & y_{(C+3)} & \cdots & y_{2C} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y_{((R-1)C+1)} & y_{((R-1)C+2)} & y_{((R-1)C+3)} & \cdots & y_{R \times C} \end{bmatrix}.$$

where $y_k = x_k$ for k = 1, 2, ..., K and if $R \times C > K$, the dummy bits are padded such that $y_k = 0 or 1$ for $k = K + 1$, $K + 2$, ..., $R \times C$. These dummy bits are pruned away from the output of the rectangular matrix after intra-row and inter-row permutations.

4.2.3.2.3.2 Intra-row and inter-row permutations

After the bits-input to the $R \times C$ rectangular matrix, the intra-row and inter-row permutations for the $R \times C$ rectangular matrix are performed stepwise by using the following algorithm with steps (1) – (6).

(1) Select a primitive root v from table 2 in section 4.2.3.2.3.1, which is indicated on the right side of the prime number p.

(2) Construct the base sequence $\langle s(j) \rangle_{j \in \{0,1,\cdots,p-2\}}$ for intra-row permutation as:

$s(j) = (v \times s(j-1)) \bmod p$, j = 1, 2,... (p - 2), and $s(0)$ = 1.

(3) Assign q_0 = 1 to be the first prime integer in the sequence $\langle q_i \rangle_{i \in \{0,1,\cdots,R-1\}}$, and determine the prime integer q_i in the sequence $\langle q_i \rangle_{i \in \{0,1,\cdots,R-1\}}$ to be a least prime integer such that g.c.d(q_i, p - 1) = 1, $q_i > 6$, and $q_i > q_{(i-1)}$ for each i = 1, 2, ..., R – 1. Here g.c.d. is greatest common divisor.

(4) Permute the sequence $\langle q_i \rangle_{i \in \{0,1,\cdots,R-1\}}$ to make the sequence $\langle r_i \rangle_{i \in \{0,1,\cdots,R-1\}}$ such that

$r_{T(i)} = q_i$, i = 0, 1, …. , R - 1,

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where $\langle T(i)\rangle_{i\in\{0,1,\cdots,R-1\}}$ is the inter-row permutation pattern defined as the one of the four kind of patterns, which are shown in table 3, depending on the number of input bits K.

Table 3: Inter-row permutation patterns for Turbo code internal interleaver

Number of input bits K	Number of rows R	Inter-row permutation patterns $<T(0), T(1), \ldots, T(R-1)>$
$(40 \le K \le 159)$	5	<4, 3, 2, 1, 0>
$(160 \le K \le 200)$ or $(481 \le K \le 530)$	10	<9, 8, 7, 6, 5, 4, 3, 2, 1, 0>
$(2281 \le K \le 2480)$ or $(3161 \le K \le 3210)$	20	<19, 9, 14, 4, 0, 2, 5, 7, 12, 18, 16, 13, 17, 15, 3, 1, 6, 11, 8, 10>
K = any other value	20	<19, 9, 14, 4, 0, 2, 5, 7, 12, 18, 10, 8, 13, 17, 3, 1, 16, 6, 15, 11>

(5) Perform the i-th ($i = 0,1, \ldots, R-1$) intra-row permutation as:

if ($C = p$) then

$U_i(j) = s((j \times r_i) \bmod(p-1))$, $j = 0, 1, \ldots, (p-2)$, and $U_i(p-1) = 0$,

where $U_i(j)$ is the original bit position of j-th permuted bit of i-th row.

end if

if ($C = p+1$) then

$U_i(j) = s((j \times r_i) \bmod(p-1))$, $j = 0, 1, \ldots, (p-2)$. $U_i(p-1) = 0$, and $U_i(p) = p$,

where $U_i(j)$ is the original bit position of j-th permuted bit of i-th row, and

if ($K = R \times C$) then

Exhange $U_{R-1}(p)$ with $U_{R-1}(0)$.

end if

end if

if ($C = p-1$) then

$U_i(j) = s((j \times r_i) \bmod(p-1)) - 1$, $j = 0, 1, \ldots, (p-2)$,

where $U_i(j)$ is the original bit position of j-th permuted bit of i-th row.

end if

(6) Perform the inter-row permutation for the rectangular matrix based on the pattern $\langle T(i)\rangle_{i\in\{0,1,\cdots,R-1\}}$,

where $T(i)$ is the original row position of the i-th permuted row.

4.2.3.2.3.3 Bits-output from rectangular matrix with pruning

After intra-row and inter-row permutations, the bits of the permuted rectangular matrix are denoted by y'_k:

$$\begin{bmatrix} y'_1 & y'_{(R+1)} & y'_{(2R+1)} & \cdots & y'_{((C-1)R+1)} \\ y'_2 & y'_{(R+2)} & y'_{(2R+2)} & \cdots & y'_{((C-1)R+2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y'_R & y'_{2R} & y'_{3R} & \cdots & y'_{C\times R} \end{bmatrix}$$

The output of the Turbo code internal interleaver is the bit sequence read out column by column from the intra-row and inter-row permuted $R \times C$ rectangular matrix starting with bit y'_1 in row 0 of column 0 and ending with bit y'_{CR} in row $R-1$ of column $C-1$. The output is pruned by deleting dummy bits that were padded to the input of the rectangular matrix before intra-row and inter row permutations, i.e. bits y'_k that corresponds to bits y_k with $k > K$ are removed from

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the output. The bits output from Turbo code internal interleaver are denoted by $x'_1, x'_2, \ldots, x'_K$, where x'_1 corresponds to the bit y'_k with smallest index k after pruning, x'_2 to the bit y'_k with second smallest index k after pruning, and so on. The number of bits output from Turbo code internal interleaver is K and the total number of pruned bits is:

$R \times C - K$.

4.2.3.3 Concatenation of encoded blocks

After the channel coding for each code block, if C_i is greater than 1, the encoded blocks are serially concatenated so that the block with lowest index r is output first from the channel coding block, otherwise the encoded block is output from channel coding block as it is. The bits output are denoted by $c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$, where i is the TrCH number and $E_i = C_i Y_i$. The output bits are defined by the following relations:

$c_{ik} = y_{i1k}$ $k = 1, 2, \ldots, Y_i$

$c_{ik} = y_{i,2,(k-Y_i)}$ $k = Y_i + 1, Y_i + 2, \ldots, 2Y_i$

$c_{ik} = y_{i,3,(k-2Y_i)}$ $k = 2Y_i + 1, 2Y_i + 2, \ldots, 3Y_i$

...

$c_{ik} = y_{i,C_i,(k-(C_i-1)Y_i)}$ $k = (C_i - 1)Y_i + 1, (C_i - 1)Y_i + 2, \ldots, C_i Y_i$

If no code blocks are input to the channel coding ($C_i = 0$), no bits shall be output from the channel coding, i.e. $E_i = 0$.

4.2.4 Radio frame size equalisation

Radio frame size equalisation is padding the input bit sequence in order to ensure that the output can be segmented in F_i data segments of same size as described in the subclause 4.2.6.

The input bit sequence to the radio frame size equalisation is denoted by $c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$, where i is TrCH number and E_i the number of bits. The output bit sequence is denoted by $t_{i1}, t_{i2}, t_{i3}, \ldots, t_{iT_i}$, where T_i is the number of bits. The output bit sequence is derived as follows:

$t_{ik} = c_{ik}$ for k = 1... E_i and

$t_{ik} = \{0, 1\}$ for k= E_i +1... T_i, if $E_i < T_i$

where

$T_i = F_i * N_i$ and

$N_i = \lceil E_i / F_i \rceil$ is the number of bits per segment after size equalisation.

4.2.5 1st interleaving

The 1st interleaving is a block interleaver with inter-column permutations. The input bit sequence to the block interleaver is denoted by $x_{i,1}, x_{i,2}, x_{i,3}, \ldots, x_{i,X_i}$, where i is TrCH number and X_i the number of bits. Here X_i is guaranteed to be an integer multiple of the number of radio frames in the TTI. The output bit sequence from the block interleaver is derived as follows:

1) select the number of columns C1 from table 4 depending on the TTI. The columns are numbered 0, 1, ..., C1 - 1 from left to right.

2) determine the number of rows of the matrix, R1 defined as

   $R1 = X_i / C1$.

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The rows of the matrix are numbered 0, 1, ..., R1 - 1 from top to bottom.

3) write the input bit sequence into the R1 × C1 matrix row by row starting with bit $x_{i,1}$ in column 0 of row 0 and ending with bit $x_{i,(R1\times C1)}$ in column C1 - 1 of row R1 – 1:

$$\begin{bmatrix} x_{i,1} & x_{i,2} & x_{i,3} & \cdots & x_{i,C1} \\ x_{i,(C1+1)} & x_{i,(C1+2)} & x_{i,(C1+3)} & \cdots & x_{i,(2\times C1)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ x_{i,((R1-1)\times C1+1)} & x_{i,((R1-1)\times C1+2)} & x_{i,((R1-1)\times C1+3)} & \cdots & x_{i,(R1\times C1)} \end{bmatrix}$$

4) Perform the inter-column permutation for the matrix based on the pattern $\langle P1_{C1}(j)\rangle_{j\in\{0,1,\ldots,C1-1\}}$ shown in table 4, where $P1_{C1}(j)$ is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by $y_{i,k}$:

$$\begin{bmatrix} y_{i,1} & y_{i,(R1+1)} & y_{i,(2\times R1+1)} & \cdots & y_{i,((C1-1)\times R1+1)} \\ y_{i,2} & y_{i,(R1+2)} & y_{i,(2\times R1+2)} & \cdots & y_{i,((C1-1)\times R1+2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y_{i,R1} & y_{i,(2\times R1)} & y_{i,(3\times R1)} & \cdots & y_{i,(C1\times R1)} \end{bmatrix}$$

5) Read the output bit sequence $y_{i,1}, y_{i,2}, y_{i,3}, \ldots, y_{i,(C1\times R1)}$ of the block interleaver column by column from the inter-column permuted R1 × C1 matrix. Bit $y_{i,1}$ corresponds to row 0 of column 0 and bit $y_{i,(R1\times C1)}$ corresponds to row R1 - 1 of column C1 - 1.

Table 4 Inter-column permutation patterns for 1st interleaving

TTI	Number of columns C1	Inter-column permutation patterns <P1C1(0), P1C1(1), ..., P1C1(C1-1)>
5ms(*1), 10 ms	1	<0>
20 ms	2	<0,1>
40 ms	4	<0,2,1,3>
80 ms	8	<0,4,2,6,1,5,3,7>

(*1) can be used for PRACH for 1.28 Mcps TDD

4.2.5.1 Relation between input and output of 1st interleaving

The bits input to the 1st interleaving are denoted by $t_{i,1}, t_{i,2}, t_{i,3}, \ldots, t_{i,T_i}$, where i is the TrCH number and T_i the number of bits. Hence, $x_{i,k} = t_{i,k}$ and $X_i = T_i$.

The bits output from the 1st interleaving are denoted by $d_{i,1}, d_{i,2}, d_{i,3}, \ldots, d_{i,T_i}$, and $d_{i,k} = y_{i,k}$.

4.2.6 Radio frame segmentation

When the transmission time interval is longer than 10 ms, the input bit sequence is segmented and mapped onto consecutive F_i radio frames. Following radio frame size equalisation the input bit sequence length is guaranteed to be an integer multiple of F_i.

The input bit sequence is denoted by $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$ where i is the TrCH number and X_i is the number bits. The F_i output bit sequences per TTI are denoted by $y_{i,n_i1}, y_{i,n_i2}, y_{i,n_i3}, \ldots, y_{i,n_iY_i}$ where n_i is the radio frame number in current TTI and Y_i is the number of bits per radio frame for TrCH i. The output sequences are defined as follows:

$y_{i,n_i,k} = x_{i,((n_i-1)Y_i)+k}$, $n_i = 1 \ldots F_i$, $k = 1 \ldots Y_i$

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where

$Y_i = (X_i / F_i)$ is the number of bits per segment.

The n_i –th segment is mapped to the n_i –th radio frame of the transmission time interval.

The input bit sequence to the radio frame segmentation is denoted by $d_{i1}, d_{i2}, d_{i3}, \ldots, d_{iT_i}$, where i is the TrCH number and T_i the number of bits. Hence, $x_{ik} = d_{ik}$ and $X_i = T_i$.

The output bit sequence corresponding to radio frame n_i is denoted by $e_{i1}, e_{i2}, e_{i3}, \ldots, e_{iN_i}$, where i is the TrCH number and N_i is the number of bits. Hence, $e_{i,k} = y_{i,n_i k}$ and $N_i = Y_i$.

4.2.7 Rate matching

Rate matching means that bits on a TrCH are repeated or punctured. Higher layers assign a rate-matching attribute for each TrCH. This attribute is semi-static and can only be changed through higher layer signalling. The rate-matching attribute is used when the number of bits to be repeated or punctured is calculated.

The number of bits on a TrCH can vary between different transmission time intervals. When the number of bits between different transmission time intervals is changed, bits are repeated to ensure that the total bit rate after TrCH multiplexing is identical to the total channel bit rate of the allocated physical channels.

If no bits are input to the rate matching for all TrCHs within a CCTrCH, the rate matching shall output no bits for all TrCHs within the CCTrCH.

Notation used in subclause 4.2.7 and subclauses:

N_{ij} : Number of bits in a radio frame before rate matching on TrCH i with transport format combination j.

$\Delta N_{i,j}$: If positive – number of bits to be repeated in each radio frame on TrCH i with transport format combination j.

If negative – number of bits to be punctured in each radio frame on TrCH i with transport format combination j.

RM_i : Semi-static rate matching attribute for TrCH i. Signalled from higher layers.

PL : Puncturing limit. This value limits the amount of puncturing that can be applied in order to minimise the number of physical channels. Signalled from higher layers. The allowed puncturing in % is actually equal to (1-PL)*100.

$N_{data,j}$: Total number of bits that are available for a CCTrCH in a radio frame with transport format combination j.

P : number of physical channels used in the current frame.

P_{max} : maximum number of physical channels allocated for a CCTrCH.

U_p : Number of data bits in the physical channel p with p = 1...P during a radio frame.

I : Number of TrCHs in a CCTrCH.

Z_{ij} : Intermediate calculation variable.

F_i : Number of radio frames in the transmission time interval of TrCH i.

n_i : Radio frame number in the transmission time interval of TrCH i ($0 \leq n_i < F_i$).

q : Average puncturing or repetition distance(normalised to only show the remaining rate matching on top of an integer number of repetitions).

$P1_F(n_i)$: The column permutation function of the 1st interleaver, $P1_F(x)$ is the original position of column with number x after permutation. P1 is defined on table 4 of section 4.2.5 (note that $P1_F$ self-inverse).

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S[n] : The shift of the puncturing or repetition pattern for radio frame n_i when $n = \mathrm{P1}_{F_i}(n_i)$.

$TF_i(j)$: Transport format of TrCH i for the transport format combination j.

$TFS(i)$: The set of transport format indexes l for TrCH i.

e_{ini} : Initial value of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.3.

e_{plus} : Increment of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.3.

e_{minus} : Decrement of variable e in the rate matching pattern determination algorithm of subclause 4.2.7.3.

b : Indicates systematic and parity bits.

b=1: Systematic bit. $X(t)$ in subclause 4.2.3.2.1.

b=2: 1st parity bit (from the upper Turbo constituent encoder). $Y(t)$ in subclause 4.2.3.2.1.

b=3: 2nd parity bit (from the lower Turbo constituent encoder). $Y'(t)$ in subclause 4.2.3.2.1.

Note: when the TTI is 5msec for 1.28Mcps, the above notation refers to a sub-frame rather than a radio frame. In this case, $F_i = 1$ and $n_i = 0$.

4.2.7.1 Determination of rate matching parameters

The following relations, defined for all TFC j, are used when calculating the rate matching pattern:

$$Z_{0,j} = 0$$

$$Z_{i,j} = \left\lfloor \frac{\left(\left(\sum_{m=1}^{i} RM_m \times N_{m,j} \right) \times N_{data,j} \right)}{\sum_{m=1}^{I} RM_m \times N_{m,j}} \right\rfloor \quad \text{for all i = 1 ... } I \text{ (1)}$$

$$\Delta N_{i,j} = Z_{i,j} - Z_{i-1,j} - N_{i,j} \quad \text{for all i = 1 ... } I$$

Puncturing can be used to minimise the required transmission capacity. The maximum amount of puncturing that can be applied is 1-PL, PL is signalled from higher layers. The possible values for N_{data} depend on the number of physical channels P_{max}, allocated to the respective CCTrCH, and on their characteristics (spreading factor, length of midamble and TFCI code word, usage of TPC and multiframe structure), which is given in [7].

For each physical channel an individual minimum spreading factor Sp_{min} is transmitted by means of the higher layers. Denote the number of data bits in each physical channel by $U_{p,Sp}$, where p indicates the sequence number $1 \le p \le P_{max}$ and Sp indicates the spreading factor with the possible values $\{16, 8, 4, 2, 1\}$ of this physical channel. The index p is described in section 4.2.12 with the following modifications: spreading factor (Q) is replaced by the minimum spreading factor Sp_{min} and k is replaced by the channelization code index at $Q = Sp_{min}$. Then, for N_{data} one of the following values in ascending order can be chosen:

$$\left\{ U_{1,S1_{\min}}, U_{1,S1_{\min}} + U_{2,S2_{\min}}, U_{1,S1_{\min}} + U_{2,S2_{\min}} + \ldots + U_{P_{\max},(SP_{\max})_{\min}} \right\}$$

Optionally, if indicated by higher layers for the UL the UE shall vary the spreading factor autonomously, so that N_{data} is one of the following values in ascending order:

$$\left\{ U_{1,16}, \ldots, U_{1,S1_{\min}}, U_{1,S1_{\min}} + U_{2,16}, \ldots, U_{1,S1_{\min}} + U_{2,S2_{\min}}, \ldots, U_{1,S1_{\min}} + U_{2,S2_{\min}} + \ldots + U_{P_{\max},16}, \ldots, U_{1,S1_{\min}} + U_{2,S2_{\min}} + \ldots + U_{P_{\max},(SP_{\max})_{\min}} \right\}$$

$N_{data,j}$ for the transport format combination j is determined by executing the following algorithm:

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SET1 = { N_{data} such that $\left(\min_{1\le y\le I}\{RM_y\}\right)\times N_{data} - PL\times\sum_{x=1}^{I} RM_x \times N_{x,j}$ is non negative }

$N_{data,j}$ = min SET1

The number of bits to be repeated or punctured, $\Delta N_{i,j}$, within one radio frame (one sub-frame when the TTI is 5msec) for each TrCH i is calculated with the relations given at the beginning of this subclause for all possible transport format combinations j and selected every radio frame (sub-frame). The number of physical channels corresponding to $N_{data,j}$ shall be denoted by P.

If $\Delta N_{i,j} = 0$ then the output data of the rate matching is the same as the input data and the rate matching algorithm of subclause 4.2.7.3 does not need to be executed.

Otherwise, the rate matching pattern is calculated with the algorithm described in subclause 4.2.7.3. For this algorithm the parameters e_{ini}, e_{plus}, e_{minus}, and X_i are needed, which are calculated according to the equations in subclauses 4.2.7.1.1 and 4.2.7.1.2.

4.2.7.1.1 Uncoded and convolutionally encoded TrCHs

a = 2

$\Delta N_i = \Delta N_{i,j}$

$X_i = N_{i,j}$

R = $\Delta N_{i,j}$ mod $N_{i,j}$ -- note: in this context $\Delta N_{i,j}$ mod $N_{i,j}$ is in the range of 0 to $N_{i,j}$-1 i.e. -1 mod 10 = 9.

if R ≠ 0 and 2×R ≤ $N_{i,j}$

then q = $\lceil N_{i,j} / R \rceil$

else

q = $\lceil N_{i,j} / (R - N_{i,j}) \rceil$

endif

NOTE 1: q is a signed quantity.

If q is even

then q' = q + gcd(|q|, F_i) / F_i -- where gcd (|q|, F_i) means greatest common divisor of |q| and F_i

NOTE 2: q' is not an integer, but a multiple of 1/8.

else

q' = q

endif

for x = 0 to F_i-1

S[$\lfloor x\times q' \rfloor$ mod F_i] = ($\lfloor x*q' \rfloor$ div F_i)

end for

$e_{ini} = (a \times S[P1_{Fi}(n_i)] \times |\Delta N_i| + 1) \bmod (a \times N_{i,j})$

$e_{plus} = a \times X_i$

$e_{minus} = a \times |\Delta N_i|$

puncturing for ΔN_i <0, repetition otherwise.

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4.2.7.1.2 Turbo encoded TrCHs

If repetition is to be performed on turbo encoded TrCHs, i.e. $\Delta N_{i,j} > 0$, the parameters in subclause 4.2.7.1.1 are used.

If puncturing is to be performed, the parameters below shall be used. Index b is used to indicate systematic (b=1), 1st parity (b=2), and 2nd parity bit (b=3).

a = 2 when b=2

a = 1 when b=3

$$\Delta N_i = \begin{cases} \lfloor \Delta N_{i,j}/2 \rfloor, & b = 2 \\ \lceil \Delta N_{i,j}/2 \rceil, & b = 3 \end{cases}$$

If ΔN_i is calculated as 0 for b=2 or b=3, then the following procedure and the rate matching algorithm of subclause 4.2.7.3 don't need to be performed for the corresponding parity bit stream.

$X_i = \lfloor N_{i,j}/3 \rfloor$,

$q = \lfloor X_i / |\Delta N_i| \rfloor$

if($q \leq 2$)

for r=0 to F_i-1

S[(3×r+b-1) mod F_i] = r mod 2;

end for

else

if q is even

then $q' = q - gcd(q, F_i)/F_i$ -- where $gcd(q, F_i)$ means greatest common divisor of q and F_i

NOTE: q' is not an integer, but a multiple of 1/8.

else $q' = q$

endif

for x=0 to $F_i - 1$

$r = \lceil x \times q' \rceil \bmod F_i$;

S[(3×r+b-1) mod F_i] = $\lceil x \times q' \rceil$ div F_i;

endfor

endif

For each radio frame, the rate-matching pattern is calculated with the algorithm in subclause 4.2.7.3, where:

X_i is as above,

$e_{ini} = (a \times S[P1\ F_i\ (n_i)] \times |\Delta N_i| + X_i) \bmod (a \times X_i)$, if $e_{ini} = 0$ then $e_{ini} = a \times X_i$

$e_{plus} = a \times X_i$

$e_{minus} = a \times |\Delta N_i|$

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4.2.7.2 Bit separation and collection for rate matching

The systematic bits of turbo encoded TrCHs shall not be punctured, the other bits may be punctured. The systematic bits, first parity bits, and second parity bits in the bit sequence input to the rate matching block are therefore separated into three sequences.

The first sequence contains:

- All of the systematic bits that are from turbo encoded TrCHs.
- From 0 to 2 first and/or second parity bits that are from turbo encoded TrCHs. These bits come into the first sequence when the total number of bits in a block after radio frame segmentation is not a multiple of three.
- Some of the systematic, first parity and second parity bits that are for trellis termination.

The second sequence contains:

- All of the first parity bits that are from turbo encoded TrCHs, except those that go into the first sequence when the total number of bits is not a multiple of three.
- Some of the systematic, first parity and second parity bits that are for trellis termination.

The third sequence contains:

- All of the second parity bits that are from turbo encoded TrCHs, except those that go into the first sequence when the total number of bits is not a multiple of three.
- Some of the systematic, first parity and second parity bits that are for trellis termination.

The second and third sequences shall be of equal length, whereas the first sequence can contain from 0 to 2 more bits. Puncturing is applied only to the second and third sequences.

The bit separation function is transparent for uncoded TrCHs, convolutionally encoded TrCHs, and for turbo encoded TrCHs with repetition. The bit separation and bit collection are illustrated in figures 4 and 5.

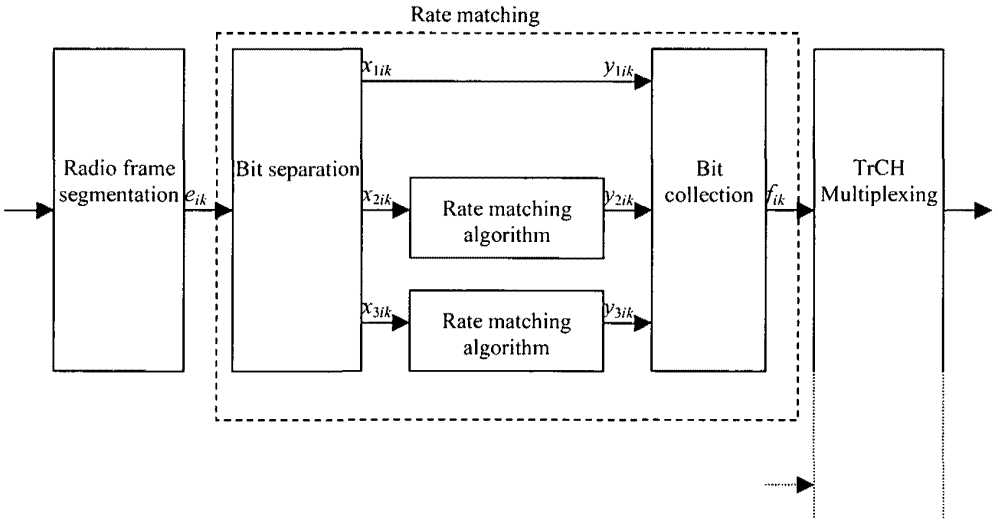


Figure 4: Puncturing of turbo encoded TrCHs

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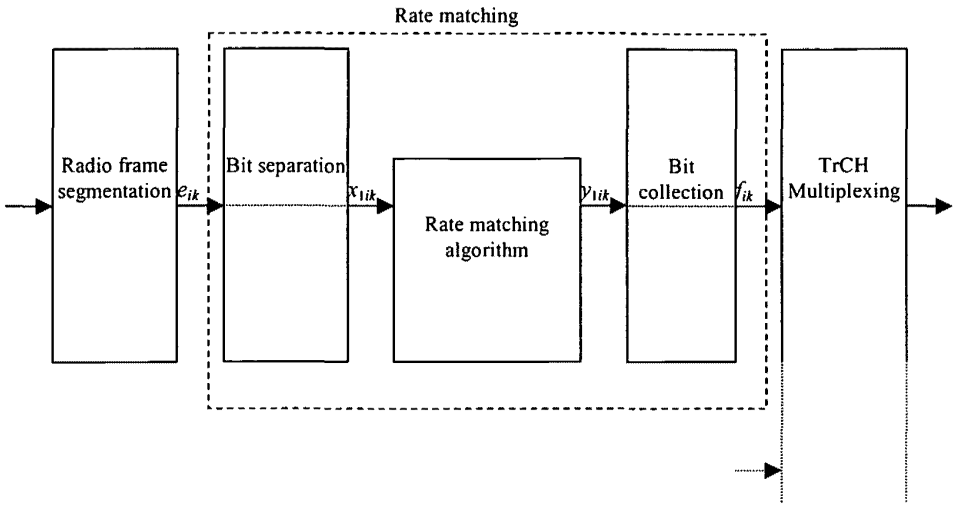


Figure 5: Rate matching for uncoded TrCHs, convolutionally encoded TrCHs, and for turbo encoded TrCHs with repetition

The bit separation is dependent on the 1st interleaving and offsets are used to define the separation for different TTIs. b indicates the three sequences defined in this section, with b=1 indicating the first sequence, b = 2 the second one, and b = 3 the third one.

The offsets α_b for these sequences are listed in table 5.

Table 5: TTI dependent offset needed for bit separation

TTI (ms)	α_1	α_2	α_3
5, 10, 40	0	1	2
20, 80	0	2	1

The bit separation is different for different radio frames in the TTI. A second offset is therefore needed. The radio frame number for TrCH i is denoted by n_i. and the offset by β_{n_i}.

Table 6: Radio frame dependent offset needed for bit separation

TTI (ms)	β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7
5, 10	0	NA	NA	NA	NA	NA	NA	NA
20	0	1	NA	NA	NA	NA	NA	NA
40	0	1	2	0	NA	NA	NA	NA
80	0	1	2	0	1	2	0	1

4.2.7.2.1 Bit separation

The bits input to the rate matching are denoted by $e_{i,1}, e_{i,2}, e_{i,3}, \ldots, e_{i,N_i}$, where i is the TrCH number and N_i is the number of bits input to the rate matching block. Note that the transport format combination number j for simplicity has been left out in the bit numbering, i.e. N_i=N_{ij}. The bits after separation are denoted by $x_{b,i,1}, x_{b,i,2}, x_{b,i,3}, \ldots, x_{b,i,X_i}$. For turbo encoded TrCHs with puncturing, b indicates the three sequences defined in section 4.2.7.2, with b=1 indicating the first sequence, and so forth. For all other cases b is defined to be 1. X_i is the number of bits in each separated bit sequence. The relation between $e_{i,k}$ and $x_{b,i,k}$ is given below.

For turbo encoded TrCHs with puncturing:

$$x_{1,i,k} = e_{i,3(k-1)+1+(\alpha_1+\beta_{n_i}) \bmod 3} \qquad k = 1, 2, 3, \ldots, X_i \qquad X_i = \lfloor N_i/3 \rfloor$$

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$x_{1,i,\lfloor N_i/3 \rfloor+k} = e_{i,3\lfloor N_i/3 \rfloor+k}$ $k = 1, \ldots, N_i \bmod 3$ Note: When (N_i mod 3) = 0 this row is not needed.

$x_{2,i,k} = e_{i,3(k-1)+1+(\alpha_2+\beta_{n_i}) \bmod 3}$ $k = 1, 2, 3, \ldots, X_i$ $X_i = \lfloor N_i/3 \rfloor$

$x_{3,i,k} = e_{i,3(k-1)+1+(\alpha_3+\beta_{n_i}) \bmod 3}$ $k = 1, 2, 3, \ldots, X_i$ $X_i = \lfloor N_i/3 \rfloor$

For uncoded TrCHs, convolutionally encoded TrCHs, and turbo encoded TrCHs with repetition:

$x_{1,i,k} = e_{i,k}$ $k = 1, 2, 3, \ldots, X_i$ $X_i = N_i$

4.2.7.2.2 Bit collection

The bits $x_{b,i,k}$ are input to the rate matching algorithm described in subclause 4.2.7.3. The bits output from the rate matching algorithm are denoted $y_{b,i,1}, y_{b,i,2}, y_{b,i,3}, \ldots, y_{b,i,Y_i}$.

Bit collection is the inverse function of the separation. The bits after collection are denoted by $z_{b,i,1}, z_{b,i,2}, z_{b,i,3}, \ldots, z_{b,i,Y_i}$. After bit collection, the bits indicated as punctured are removed and the bits are then denoted by $f_{i,1}, f_{i,2}, f_{i,3}, \ldots, f_{i,V_i}$, where i is the TrCH number and $V_i = N_{i,j}+\Delta N_{i,j}$. The relations between $y_{b,i,k}$, $z_{b,i,k}$, and $f_{i,k}$ are given below.

For turbo encoded TrCHs with puncturing (Y_i=X_i):

$z_{i,3(k-1)+1+(\alpha_1+\beta_{n_i}) \bmod 3} = y_{1,i,k}$ $k = 1, 2, 3, \ldots, Y_1$

$z_{i,3\lfloor N_i/3 \rfloor+k} = y_{1,i,\lfloor N_i/3 \rfloor+k}$ $k = 1, \ldots, N_i \bmod 3$ Note: When (N_i mod 3) = 0 this row is not needed.

$z_{i,3(k-1)+1+(\alpha_2+\beta_{n_i}) \bmod 3} = y_{2,i,k}$ $k = 1, 2, 3, \ldots, Y_i$

$z_{i,3(k-1)+1+(\alpha_3+\beta_{n_i}) \bmod 3} = y_{3,i,k}$ $k = 1, 2, 3, \ldots, Y_i$

After the bit collection, bits $z_{i,k}$ with value δ, where $\delta \in \{0, 1\}$, are removed from the bit sequence. Bit $f_{i,1}$ corresponds to the bit $z_{i,k}$ with smallest index k after puncturing, bit $f_{i,2}$ corresponds to the bit $z_{i,k}$ with second smallest index k after puncturing, and so on.

For uncoded TrCHs, convolutionally encoded TrCHs, and turbo encoded TrCHs with repetition:

$z_{i,k} = y_{1,i,k}$ $k = 1, 2, 3, \ldots, Y_i$

When repetition is used, $f_{i,k}$=$z_{i,k}$ and Y_i=V_i.

When puncturing is used, Y_i=X_i and bits $z_{i,k}$ with value δ, where $\delta \in \{0, 1\}$, are removed from the bit sequence. Bit $f_{i,1}$ corresponds to the bit $z_{i,k}$ with smallest index k after puncturing, bit $f_{i,2}$ corresponds to the bit $z_{i,k}$ with second smallest index k after puncturing, and so on.

4.2.7.3 Rate matching pattern determination

The bits input to the rate matching are denoted by $x_{i,1}, x_{i,2}, x_{i,3}, \ldots, x_{i,X_i}$, where i is the TrCH and X_i is the parameter given in subclauses 4.2.7.1.1 and 4.2.7.1.2.

NOTE: The transport format combination number j for simplicity has been left out in the bit numbering.

The rate matching rule is as follows:

if puncturing is to be performed

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```
    e = e_ini     -- initial error between current and desired puncturing ratio
    m = 1         -- index of current bit
    do while m <= X_i
      e = e - e_minus       -- update error
      if e <= 0 then        -- check if bit number m should be punctured
        set bit x_i,m to δ where δ∉{0, 1}
        e = e + e_plus      -- update error
      end if
      m = m + 1             --  next bit
    end do
  else
    e = e_ini     -- initial error between current and desired puncturing ratio
    m = 1         -- index of current bit
    do while m <= X_i
      e = e - e_minus       -- update error
      do while e <= 0       -- check if bit number m should be repeated
        repeat bit x_i,m
        e = e + e_plus      -- update error
      end do
      m = m + 1             --  next bit
    end do
  end if
```

A repeated bit is placed directly after the original one.

4.2.8 TrCH multiplexing

Every 10 ms, one radio frame from each TrCH is delivered to the TrCH multiplexing. These radio frames are serially multiplexed into a coded composite transport channel (CCTrCH). If the TTI is smaller than 10ms, then no TrCH multiplexing is performed.

The bits input to the TrCH multiplexing are denoted by $f_{i,1}, f_{i,2}, f_{i,3}, \ldots, f_{i,V_i}$, where i is the TrCH id number and V_i is the number of bits in the radio frame of TrCH i. The number of TrCHs is denoted by I. The bits output from TrCH multiplexing are denoted by $h_1, h_2, h_3, \ldots, h_S$, where S is the number of bits, i.e. $S = \sum_i V_i$. The TrCH multiplexing is defined by the following relations:

$h_k = f_{1,k}$ $\quad k = 1, 2, \ldots, V_1$

$h_k = f_{2,(k-V_1)}$ $\quad k = V_1+1, V_1+2, \ldots, V_1+V_2$

$h_k = f_{3,(k-(V_1+V_2))}$ $\quad k = (V_1+V_2)+1, (V_1+V_2)+2, \ldots, (V_1+V_2)+V_3$

...

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$h_k = f_{1,(k-(V_1+V_2+...+V_{1-1}))}$ $k = (V_1+V_2+...+V_{1-1})+1, (V_1+V_2+...+V_{1-1})+2, ..., (V_1+V_2+...+V_{1-1})+V_1$

4.2.9 Bit Scrambling

The bits output from the TrCH multiplexer are scrambled in the bit scrambler. The bits input to the bit scrambler are denoted by $h_1, h_2, h_3, \ldots, h_S$, where S is the number of bits input to the bit scrambling block equal to the total number of bits on the CCTrCH. The bits after bit scrambling are denoted $s_1, s_2, s_3, \ldots, s_S$.

Bit scrambling is defined by the following relation:

$$s_k = h_k \oplus p_k \quad k = 1,2\ldots,S$$

and p_k results from the following operation:

$$p_k = \left(\sum_{i=1}^{16} g_i \cdot p_{k-i}\right) \bmod 2; \quad p_k = 0; k < 1 \; ; \quad p_1 = 1; \quad g = \{0,0,0,0,0,0,0,0,0,0,0,1,0,1,1,0,1\}$$

4.2.10 Physical channel segmentation

When more than one PhCH is used, physical channel segmentation divides the bits among the different PhCHs. The bits input to the physical channel segmentation are denoted by $s_1, s_2, s_3, \ldots, s_S$, where S is the number of bits input to the physical channel segmentation block. The number of PhCHs after rate matching is denoted by P, as defined in subclause 4.2.7.1.

The bits after physical channel segmentation are denoted $u_{p,1}, u_{p,2}, u_{p,3}, \ldots, u_{p,U_p}$, where p is PhCH number and U_p is the in general variable number of bits in the respective radio frame for each PhCH. The relation between s_k and $u_{p,k}$ is given below.

Bits on first PhCH after physical channel segmentation:

$u_{1,k} = s_k$ $k = 1, 2, \ldots, U_1$

Bits on second PhCH after physical channel segmentation:

$u_{2,k} = s_{(k+U_1)}$ $k = 1, 2, \ldots, U_2$

...

Bits on the Pth PhCH after physical channel segmentation:

$u_{P,k} = s_{(k+U_1+...+U_{P-1})}$ $k = 1, 2, \ldots, U_P$

4.2.11 2nd interleaving

The 2nd interleaving is a block interleaver and consists of bits input to a matrix with padding, the inter-column permutation for the matrix and bits output from the matrix with pruning. The 2nd interleaving can be applied jointly to all data bits transmitted during one frame, or separately within each timeslot, on which the CCTrCH is mapped. The selection of the 2nd interleaving scheme is controlled by higher layer.

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4.2.11.1 Frame related 2nd interleaving

In case of frame related 2nd interleaving, the bits input to the block interleaver are denoted by $x_1, x_2, x_3, \ldots, x_U$, where U is the total number of bits after TrCH multiplexing transmitted during the respective radio frame with $S = U = \sum_p U_p$.

The relation between x_k and the bits $u_{p,k}$ in the respective physical channels is given below:

$x_k = u_{1,k}$ $\quad k = 1, 2, \ldots, U_1$

$x_{(k+U_1)} = u_{2,k}$ $\quad k = 1, 2, \ldots, U_2$

...

$x_{(k+U_1+\ldots+U_{P-1})} = u_{P,k}$ $\quad k = 1, 2, \ldots, U_P$

The following steps have to be performed once for each CCTrCH:

(1) Assign C2 = 30 to be the number of columns of the matrix. The columns of the matrix are numbered 0, 1, 2, ..., C2 - 1 from left to right.

(2) Determine the number of rows of the matrix, R2, by finding minimum integer R2 such that:

$U \leq$ R2 X C2.

The rows of rectangular matrix are numbered 0, 1, 2, ..., R2 - 1 from top to bottom.

(3) Write the input bit sequence $x_1, x_2, x_3, \ldots, x_U$ into the R2 × C2 matrix row by row starting with bit y_1 in column 0 of row 0:

$$\begin{bmatrix} y_1 & y_2 & y_3 & \cdots & y_{C2} \\ y_{(C2+1)} & y_{(C2+2)} & y_{(C2+3)} & \cdots & y_{(2\times C2)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ y_{((R2-1)\times C2+1)} & y_{((R2-1)\times C2+2)} & y_{((R2-1)\times C2+3)} & \cdots & y_{(R2\times C2)} \end{bmatrix}$$

where $y_k = x_k$ for $k = 1, 2, \ldots, U$ and if R2 × C2 > U, the dummy bits are padded such that y_k = 0 or 1 for $k = U+1, U+2, \ldots,$ R2 × C2. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

(4) Perform the inter-column permutation for the matrix based on the pattern $\langle P2(j) \rangle_{j \in \{0,1,\ldots,C2-1\}}$ that is shown in table 7, where $P_2(j)$ is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by y'_k.

$$\begin{bmatrix} y'_1 & y'_{(R2+1)} & y'_{(2\times R2+1)} & \cdots & y'_{((C2-1)\times R2+1)} \\ y'_2 & y'_{(R2+2)} & y'_{(2\times R2+2)} & \cdots & y'_{((C2-1)\times R2+2)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ y'_{R2} & y'_{(2\times R2)} & y'_{(3\times R2)} & \cdots & y'_{(C2\times R2)} \end{bmatrix}$$

(5) The output of the block interleaver is the bit sequence read out column by column from the inter-column permuted R2 × C2 matrix. The output is pruned by deleting dummy bits that were padded to the input of the matrix before the inter-column permutation, i.e. bits y'_k that corresponds to bits y_k with $k > U$ are removed from the output. The bits at the output of the block interleaver are denoted by $z_1, z_2, \ldots, z_U$, where z_1

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corresponds to the bit y'_k with smallest index k after pruning, z_2 to the bit y'_k with second smallest index k after pruning, and so on.

The bits $z_1, z_2, \ldots, z_U$ shall be segmented as follows:

$u_{1,k} = z_k$ $k = 1, 2, \ldots, U_1$

$u_{2,k} = z_{(k+U_1)}$ $k = 1, 2, \ldots, U_2$

...

$u_{P,k} = z_{(k+U_1+\ldots+U_{P-1})}$ $k = 1, 2, \ldots, U_P$

The bits after frame related 2nd interleaving are denoted by $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$, where t refers to the timeslot sequence number and U_t is the number of bits transmitted in this timeslot during the respective radio frame.

Let T be the number of time slots in a CCTrCH during the respective radio frame (where for 1.28Mcps TDD, the respective radio frame includes subframes 1 and 2), and $t = 1, \ldots, T$. The physical layer shall assign the time slot sequence number t in ascending order of the allocated time slots in the CCTrCH in the respective radio frame. In time slot t, R_t refers to the number of physical channels within the respective time slot and $r = 1, \ldots, R_t$. The relation between r and t and the physical channel sequence number p as detailed in 4.2.12.1 is given by:

$p = r$ $t = 1$

$p = R_1 + R_2, \ldots, R_{t-1} + r$ $1 < t \le T$

Defining the relation $u_{t,r,k} = u_{p,k}$ and denoting U_{tr} as the number of bits for physical channel r in time slot t, the relation between $v_{t,k}$ and $u_{t,r,k}$ is given below:

$v_{t,k} = u_{t,1,k}$ $k = 1, 2, \ldots, U_{t1}$

$v_{t,(k+U_{t1})} = u_{t,2,k}$ $k = 1, 2, \ldots, U_{t2}$

...

$v_{t,(k+U_{t1}+\ldots+U_{t(R_t-1)})} = u_{t,R_t,k}$ $k = 1, 2, \ldots, U_{tR_t}$

4.2.11.2 Timeslot related 2nd interleaving

In case of timeslot related 2nd interleaving, the bits input to the block interleaver are denoted by $x_{t,1}, x_{t,2}, x_{t,3}, \ldots, x_{t,U_t}$, where t is the timeslot sequence number, and U_t is the number of bits transmitted in this timeslot during the respective radio frame.

Let T be the number of time slots in a CCTrCH during the respective radio frame (where for 1.28Mcps TDD, the respective radio frame includes subframes 1 and 2), and $t = 1, \ldots, T$. The physical layer shall assign the time slot sequence number t in ascending order of the allocated time slots in the CCTrCH in the respective radio frame. In timeslot t, R_t refers to the number of physical channels within the respective timeslot and $r = 1, \ldots, R_t$. The relation between r and t and the physical channel sequence number p as detailed in 4.2.12.1 is given by:

$p = r$ $t = 1$

$p = R_1 + R_2, \ldots, R_{t-1} + r$ $1 < t \le T$

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Defining the relation $u_{t,r,k} = u_{p,k}$ and denoting U_{tr} as the number of bits for physical channel r in time slot t, the relation between $x_{t,k}$ and $u_{t,r,k}$ is given below:

$x_{t,k} = u_{t,1,k}$ $\quad k = 1, 2, \ldots, U_{t1}$

$x_{t,(k+U_{t1})} = u_{t,2,k}$ $\quad k = 1, 2, \ldots, U_{t2}$

...

$x_{t,(k+U_{t1}+\ldots+U_{t(R_t-1)})} = u_{t,R_t,k}$ $\quad k = 1, 2, \ldots, U_{tR_t}$

The following steps have to be performed for each timeslot t, on which the respective CCTrCH is mapped:

(1) Assign C2 = 30 to be the number of columns of the matrix. The columns of the matrix are numbered 0, 1, 2, ..., C2 - 1 from left to right.

(2) Determine the number of rows of the matrix, R2, by finding minimum integer R2 such that:

$U_t \leq R2 \times C2$.

The rows of rectangular matrix are numbered 0, 1, 2, ..., R2 - 1 from top to bottom.

(3) Write the input bit sequence $x_{t,1}, x_{t,2}, x_{t,3}, \ldots, x_{t,U_t}$ into the R2 × C2 matrix row by row starting with bit $y_{t,1}$ in column 0 of row 0:

$$\begin{bmatrix} y_{t,1} & y_{t,2} & y_{t,3} & \cdots & y_{t,C2} \\ y_{t,(C2+1)} & y_{t,(C2+2)} & y_{t,(C2+3)} & \cdots & y_{t,(2\times C2)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ y_{t,((R2-1)\times C2+1)} & y_{t,((R2-1)\times C2+2)} & y_{t,((R2-1)\times C2+3)} & \cdots & y_{t,(R2\times C2)} \end{bmatrix}$$

where $y_{t,k} = x_{t,k}$ for $k = 1, 2, \ldots, U_t$ and if $R2 \times C2 > U_t$, the dummy bits are padded such that $y_{t,k}$ = 0 or 1 for $k = U_t + 1, U_t + 2, \ldots, R2 \times C2$. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

(4) Perform the inter-column permutation for the matrix based on the pattern $\langle P2(j) \rangle_{j \in \{0,1,\ldots,C2-1\}}$ that is shown in table 7, where P2(*j*) is the original column position of the *j*-th permuted column. After permutation of the columns, the bits are denoted by $y'_{t,k}$.

$$\begin{bmatrix} y'_{t,1} & y'_{t,(R2+1)} & y'_{t,(2\times R2+1)} & \cdots & y'_{t,((C2-1)\times R2+1)} \\ y'_{t,2} & y'_{t,(R2+2)} & y'_{t,(2\times R2+2)} & \cdots & y'_{t,((C2-1)\times R2+2)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ y'_{t,R2} & y'_{t,(2\times R2)} & y'_{t,(3\times R2)} & \cdots & y'_{t,(C2\times R2)} \end{bmatrix}$$

(5) The output of the block interleaver is the bit sequence read out column by column from the inter-column permuted R2 × C2 matrix. The output is pruned by deleting dummy bits that were padded to the input of the matrix before the inter-column permutation, i.e. bits $y'_{t,k}$ that corresponds to bits $y_{t,k}$ with $k > U_t$ are removed from the output. The bits after time slot 2nd interleaving are denoted by $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$, where $v_{t,1}$ corresponds to the bit $y'_{t,k}$ with smallest index k after pruning, $v_{t,2}$ to the bit $y'_{t,k}$ with second smallest index k after pruning, and so on.

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Table 7 Inter-column permutation pattern for 2nd interleaving

Number of Columns C2	Inter-column permutation pattern < P2(0), P2(1), ..., P2(C2-1) >
30	<0, 20, 10, 5, 15, 25, 3, 13, 23, 8, 18, 28, 1, 11, 21, 6, 16, 26, 4, 14, 24, 19, 9, 29, 12, 2, 7, 22, 27, 17>

4.2.11A Sub-frame segmentation for the 1.28 Mcps option

In the 1.28Mcps TDD, it is needed to add a sub-frame segmentation unit between 2nd interleaving unit and physical channel mapping unit when the TTI of the CCTrCh is greater than 5msec. In this case, the operation of rate-matching guarantees that the size of bit streams is an even number and can be subdivided into 2 sub-frames. The transport channel multiplexing structure for uplink and downlink is shown in figure 1A.

The input to the sub-frame segmentation unit is segmented into timeslot chunks, where each timeslot chunk contains all of the bits that are to be transmitted in a given timeslot position in both of the sub-frames.

The input bit sequence is denoted by $x_{i1}, x_{i2}, x_{i3}, \ldots, x_{iX_i}$ where i is the timeslot number and X_i is the number of bits transmitted in timeslot i in a radio frame. The two output bit sequences per radio frame are denoted by $y_{i,n,1}, y_{i,n,2}, y_{i,n,3}, \ldots, y_{i,n,Y_i}$ where n is the sub-frame number in current radio frame and Y_i is the number of bits per sub-frame for timeslot i. The output sequences are defined as follows:

$y_{i,n,k} = x_{i,((n-1).Y_i)+k}$, n = 1 or 2, k = 1...$Y_i$

where

$Y_i = (X_i / 2)$ is the number of bits in timeslot i per sub-frame,

x_{ik} is the kth bit of the input bit sequence and

$y_{i,n,k}$ is the kth bit of the output bit sequence corresponding to the nth sub-frame

4.2.12 Physical channel mapping

4.2.12.1 Physical channel mapping for the 3.84 Mcps option

The PhCH for both uplink and downlink is defined in [7]. The bits after physical channel mapping are denoted by $w_{p,1}, w_{p,2}, \ldots, w_{p,U_p}$, where p is the PhCH number corresponding to the sequence number $1 \le p \le P$ of this physical channel as detailed below, U_p is the number of bits in one radio frame for the respective PhCH, and $P \le P_{max}$. The bits $w_{p,k}$ are mapped to the PhCHs so that the bits for each PhCH are transmitted over the air in ascending order with respect to k.

The physical layer shall assign the physical channel sequence number p to the physical channels of the CCTrCH in the respective radio frame, treating each allocated timeslot in ascending order. If within a timeslot there are multiple physical channels they shall first be ordered in ascending order of the spreading factor (Q) and subsequently by channelisation code index (k), as shown in [9].

The mapping of the bits $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$ is performed like block interleaving, writing the bits into columns, but a PhCH with an odd number is filled in forward order, whereas a PhCH with an even number is filled in reverse order.

The mapping scheme, as described in the following subclause, shall be applied individually for each timeslot t used in the current frame. Therefore, the bits $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$ are assigned to the bits of the physical channels $w_{t,1,1...U_{t1}}, w_{t,2,1...U_{t2}}, \ldots, w_{t,P_t,1...U_{tP_t}}$ in each timeslot.

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In uplink there are at most two codes allocated (P≤2). If there is only one code, the same mapping as for downlink is applied. Denote SF1 and SF2 the spreading factors used for code 1 and 2, respectively. For the number of consecutive bits to assign per code bs_k the following rule is applied:

if

SF1 >= SF2 then $bs_1 = 1$; $bs_2 =$ SF1/SF2 ;

else

SF2 > SF1 then $bs_1 =$ SF2/SF1; $bs_2 = 1$;

end if

In the downlink case bs_p is 1 for all physical channels.

4.2.12.1.1 Mapping scheme

Notation used in this subclause:

P_t: number of physical channels for timeslot t , $P_t = 1..2$ for uplink ; $P_t = 1...16$ for downlink

$U_{t,p}$: capacity in bits for the physical channel p in timeslot t

U_t: total number of bits to be assigned for timeslot t

bs_p: number of consecutive bits to assign per code

for downlink all $bs_p = 1$

for uplink if SF1 >= SF2 then $bs_1 = 1$; $bs_2 =$ SF1/SF2 ;

if SF2 > SF1 then $bs_1 =$ SF2/SF1; $bs_2 = 1$;

fb_p: number of already written bits for each code

pos: intermediate calculation variable

```
for   p=1   to P_t                    -- reset number of already written bits for every physical channel
   fb_p = 0
end for
p = 1                                 -- start with PhCH #1
for k=1   to U_t
   do while (fb_p == U_t,p)           -- physical channel filled up already ?
      p = (p mod P_t) + 1;
   end do
   if (p mod 2) == 0
      pos = U_t,p - fb_p              -- reverse order
   else
      pos = fb_p + 1                  -- forward order
   endif
   w_t,p,pos = v_t,k                  -- assignment
   fb_p = fb_p + 1                    -- Increment number of already written bits
```


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if (fb_p mod bs_p) == 0 -- Conditional change to the next physical channel

p = (p mod P_t) + 1;

end if

end for

4.2.12.2 Physical channel mapping for the 1.28 Mcps option

The bit streams from the sub-frame segmentation unit are mapped onto code channels of time slots in sub-frames.

The bits after physical channel mapping are denoted by $w_{p1}, w_{p2}, \ldots, w_{pU_p}$, where p is the PhCH number and Up is the number of bits in one sub-frame for the respective PhCH. The bits wpk are mapped to the PhCHs so that the bits for each PhCH are transmitted over the air in ascending order with respect to k.

The mapping of the bits $y_{t,n,1}$, $y_{t,n,2}, y_{t,n,3}, \ldots, y_{t,n,Ut}$ is performed like block interleaving, writing the bits into columns, but a PhCH with an odd number is filled in forward order, were as a PhCH with an even number is filled in reverse order.

The mapping scheme, as described in the following subclause, shall be applied individually for each timeslot t used in the current subframe. Therefore, the bits $y_{t,n,1}$, $y_{t,n,2}, y_{t,n,3}, \ldots, y_{t,n,Ut}$ are assigned to the bits of the physical channels $w_{t1,1\ldots U_{t1}}, w_{t2,1\ldots U_{t2}}, \ldots, w_{tP_t,1\ldots U_{tP_t}}$ in each timeslot.

In uplink there are at most two codes allocated (P≤2). If there is only one code, the same mapping as for downlink is applied. Denote SF1 and SF2 the spreading factors used for code 1 and 2, respectively. For the number of consecutive bits to assign per code bsk the following rule is applied:

if

SF1 >= SF2 then $bs_1 = 1$; bs_2 = SF1/SF2 ;

else

SF2 > SF1 then bs_1 = SF2/SF1; $bs_2 = 1$;

end if

In the downlink case bs_p is 1 for all physical channels.

4.2.12.2.1 Mapping scheme

Notation used in this subclause:

P_t: number of physical channels for timeslot t , P_t = 1..2 for uplink ; P_t = 1...16 for downlink

U_{tp}: capacity in bits for the physical channel p in timeslot t in the current sub-frame

U_t.: total number of bits to be assigned for timeslot t in the current sub-frame

n = index of the current sub-frame (1 or 2)

bs_p: number of consecutive bits to assign per code

for downlink all $bs_p = 1$

for uplink if SF1 >= SF2 then $bs_1 = 1$; bs_2 = SF1/SF2 ;

if SF2 > SF1 then bs_1 = SF2/SF1; $bs_2 = 1$;

fb_p: number of already written bits for each code

pos: intermediate calculation variable

for p=1 to P_t -- reset number of already written bits for every physical channel

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$fb_p = 0$

end for

p = 1 -- start with PhCH #1

for k=1 to U_t.

do while ($fb_p == U_{t,p}$) -- physical channel filled up already ?

p = (p mod P_t) + 1 ;

end do

if (p mod 2) == 0

pos = $U_{t,p} - fb_p$ -- reverse order

else

pos = $fb_p + 1$ -- forward order

end if

$w_{tp,pos} = y_{t,n,k}$ -- assignment

$fb_p = fb_p + 1$ -- Increment number of already written bits

If (fb_p mod bs_p) == 0 -- Conditional change to the next physical channel

p = (p mod P t) + 1 ;

end if

end for

4.2.13 Multiplexing of different transport channels onto one CCTrCH, and mapping of one CCTrCH onto physical channels

Different transport channels can be encoded and multiplexed together into one Coded Composite Transport Channel (CCTrCH). The following rules shall apply to the different transport channels which are part of the same CCTrCH:

1) Transport channels multiplexed into one CCTrCh shall have co-ordinated timings. When the TFCS of a CCTrCH is changed because one or more transport channels are added to the CCTrCH or reconfigured within the CCTrCH, or removed from the CCTrCH, the change may only be made at the start of a radio frame with CFN fulfilling the relation

   CFN mod $F_{max} = 0$,

   where F_{max} denotes the maximum number of radio frames within the transmission time intervals of all transport channels which are multiplexed into the same CCTrCH, including any transport channels *i* which are added reconfigured or have been removed, and CFN denotes the connection frame number of the first radio frame of the changed CCTrCH.

   After addition or reconfiguration of a transport channel *i* within a CCTrCH, the TTI of transport channel *i* may only start in radio frames with CFN fulfilling the relation

   CFN_i mod $F_i = 0$.

2) Different CCTrCHs cannot be mapped onto the same physical channel.

3) One CCTrCH shall be mapped onto one or several physical channels.

4) Dedicated Transport channels and common transport channels cannot be multiplexed into the same CCTrCH.

5) For the common transport channels, only the FACH and PCH may belong to the same CCTrCH.

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6) Each CCTrCH carrying a BCH shall carry only one BCH and shall not carry any other Transport Channel.

7) Each CCTrCH carrying a RACH shall carry only one RACH and shall not carry any other Transport Channel.

Hence, there are two types of CCTrCH.

CCTrCH of dedicated type, corresponding to the result of coding and multiplexing of one or several DCH.

CCTrCH of common type, corresponding to the result of the coding and multiplexing of a common channel, i.e. RACH and USCH in the uplink and DSCH, BCH, FACH or PCH in the downlink, respectively.

Transmission of TFCI is possible for CCTrCH containing Transport Channels of:

- dedicated type;
- USCH type;
- DSCH type;
- FACH and/or PCH type.

4.2.13.1 Allowed CCTrCH combinations for one UE

4.2.13.1.1 Allowed CCTrCH combinations on the uplink

The following CCTrCH combinations for one UE are allowed, also simultaneously:

1) several CCTrCH of dedicated type;

2) several CCTrCH of common type.

4.2.13.1.2 Allowed CCTrCH combinations on the downlink

The following CCTrCH combinations for one UE are allowed, also simultaneously:

3) several CCTrCH of dedicated type;

4) several CCTrCH of common type.

4.2.14 Transport format detection

Transport format detection can be performed both with and without Transport Format Combination Indicator (TFCI). If a TFCI is transmitted, the receiver detects the transport format combination from the TFCI. When no TFCI is transmitted, so called blind transport format detection may be used, i.e. the receiver side uses the possible transport format combinations as a priori information.

4.2.14.1 Blind transport format detection

Blind Transport Format Detection is optional both in the UE and the UTRAN. Therefore, for all CCTrCH a TFCI shall be transmitted, including the possibility of a TFCI code word length zero, if only one TFC is defined.

4.2.14.2 Explicit transport format detection based on TFCI

4.2.14.2.1 Transport Format Combination Indicator (TFCI)

The Transport Format Combination Indicator (TFCI) informs the receiver of the transport format combination of the CCTrCHs. As soon as the TFCI is detected, the transport format combination, and hence the individual transport channels' transport formats are known, and decoding of the transport channels can be performed.

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4.3 Coding for layer 1 control for the 3.84 Mcps option

4.3.1 Coding of transport format combination indicator (TFCI)

Encoding of the TFCI depends on its length. If there are 6-10 bits of TFCI the channel encoding is done as described in subclause 4.3.1.1. Also specific coding of less than 6 bits is possible as explained in subclause 4.3.1.2.

4.3.1.1 Coding of long TFCI lengths

The TFCI is encoded using a (32, 10) sub-code of the second order Reed-Muller code. The coding procedure is as shown in figure 6.

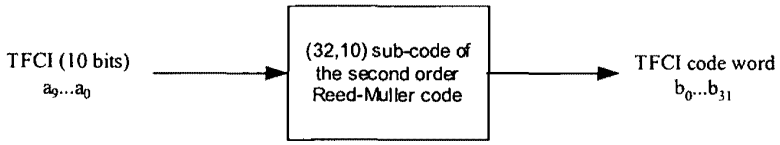


Figure 6: Channel coding of the TFCI bits

If the TFCI consists of less than 10 bits, it is padded with zeros to 10 bits, by setting the most significant bits to zero. TFCI is encoded by the (32,10) sub-code of second order Reed-Muller code. The code words of the (32,10) sub-code of second order Reed-Muller code are linear combination of some among 10 basis sequences. The basis sequences are as follows in table 8.

Table 8: Basis sequences for (32,10) TFCI code

I	$M_{i,0}$	$M_{i,1}$	$M_{i,2}$	$M_{i,3}$	$M_{i,4}$	$M_{i,5}$	$M_{i,6}$	$M_{i,7}$	$M_{i,8}$	$M_{i,9}$
0	1	0	0	0	0	1	0	0	0	0
1	0	1	0	0	0	1	1	0	0	0
2	1	1	0	0	0	1	0	0	0	1
3	0	0	1	0	0	1	1	0	1	1
4	1	0	1	0	0	1	0	0	0	1
5	0	1	1	0	0	1	0	0	1	0
6	1	1	1	0	0	1	0	1	0	0
7	0	0	0	1	0	1	0	1	1	0
8	1	0	0	1	0	1	1	1	1	0
9	0	1	0	1	0	1	1	0	1	1
10	1	1	0	1	0	1	0	0	1	1
11	0	0	1	1	0	1	0	1	1	0
12	1	0	1	1	0	1	0	1	0	1
13	0	1	1	1	0	1	1	0	0	1
14	1	1	1	1	0	1	1	1	1	1
15	1	0	0	0	1	1	1	1	0	0
16	0	1	0	0	1	1	1	1	0	1
17	1	1	0	0	1	1	1	0	1	0
18	0	0	1	0	1	1	0	1	1	1
19	1	0	1	0	1	1	0	1	0	1
20	0	1	1	0	1	1	0	0	1	1
21	1	1	1	0	1	1	0	1	1	1
22	0	0	0	1	1	1	0	1	0	0
23	1	0	0	1	1	1	1	1	0	1
24	0	1	0	1	1	1	1	0	1	0
25	1	1	0	1	1	1	1	0	0	1
26	0	0	1	1	1	1	0	0	1	0
27	1	0	1	1	1	1	1	1	0	0
28	0	1	1	1	1	1	1	1	1	0
29	1	1	1	1	1	1	1	1	1	1
30	0	0	0	0	0	1	0	0	0	0
31	0	0	0	0	1	1	1	0	0	0

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The TFCI bits a_0 , a_1 , a_2 , a_3 , a_4 , a_5 , a_6 , a_7 , a_8 , a_9 (where a_0 is LSB and a_9 is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated radio frame.

The output TFCI code word bits b_i are given by:

$$b_i = \sum_{n=0}^{9} (a_n \times M_{i,n}) \bmod 2$$

where $i = 0,\ldots,31$. $N_{TFCI\ code\ word} = 32$.

4.3.1.2 Coding of short TFCI lengths

4.3.1.2.1 Coding very short TFCIs by repetition

If the number of TFCI bits is 1 or 2, then repetition will be used for coding. In this case each bit is repeated to a total of 4 times giving 4-bit transmission ($N_{TFCI\ code\ word}$=4) for a single TFCI bit and 8-bit transmission ($N_{TFCI\ code\ word}$=8) for 2 TFCI bits. The TFCI bit(s) a_0 (or a_0 and a_1 where a_0 is the LSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated radio frame.

In the case of $N_{TFCI\ code\ word}$=4, the TFCI codeword $\{b_0, b_1, b_2, b_3\}$ is equal to the sequence $\{a_0, a_0, a_0, a_0\}$.

In the case of $N_{TFCI\ code\ word}$=8, the TFCI codeword $\{b_0, b_1, \ldots, b_7\}$ is equal to the sequence $\{a_0, a_1, a_0, a_1, a_0, a_1, a_0, a_1\}$.

4.3.1.2.2 Coding short TFCIs using bi-orthogonal codes

If the number of TFCI bits is in the range 3 to 5 the TFCI is encoded using a (16, 5) bi-orthogonal (or first order Reed-Muller) code. The coding procedure is as shown in figure 7.

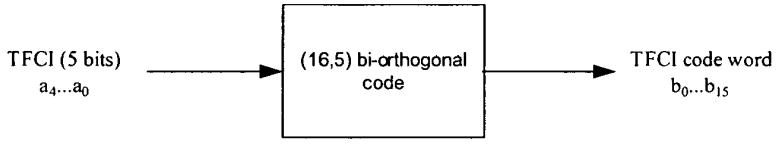


Figure 7: Channel coding of short length TFCI bits

If the TFCI consists of less than 5 bits, it is padded with zeros to 5 bits, by setting the most significant bits to zero. The code words of the (16,5) bi-orthogonal code are linear combinations of 5 basis sequences as defined in table 9.

Table 9: Basis sequences for (16,5) TFCI code

i	$M_{i,0}$	$M_{i,1}$	$M_{i,2}$	$M_{i,3}$	$M_{i,4}$
0	1	0	0	0	1
1	0	1	0	0	1
2	1	1	0	0	1
3	0	0	1	0	1
4	1	0	1	0	1
5	0	1	1	0	1
6	1	1	1	0	1
7	0	0	0	1	1
8	1	0	0	1	1
9	0	1	0	1	1
10	1	1	0	1	1
11	0	0	1	1	1
12	1	0	1	1	1
13	0	1	1	1	1
14	1	1	1	1	1
15	0	0	0	0	1

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The TFCI bits a_0 , a_1 , a_2 , a_3 , a_4 (where a_0 is LSB and a_4 is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated radio frame.

The output code word bits b_j are given by:

$$b_i = \sum_{n=0}^{4} (a_n \times M_{i,n}) \bmod 2$$

where $i = 0,\ldots,15$. $N_{TFCI\ code\ word} = 16$.

4.3.1.3 Mapping of TFCI code word

The mapping of the TFCI code word to the TFCI bit positions in a timeslot shall be as follows.

Denote the number of bits in the TFCI code word by $N_{TFCI\ code\ word}$, denote the TFCI code word bits by b_k where k=0... $N_{TFCI\ code\ word}$ -1.

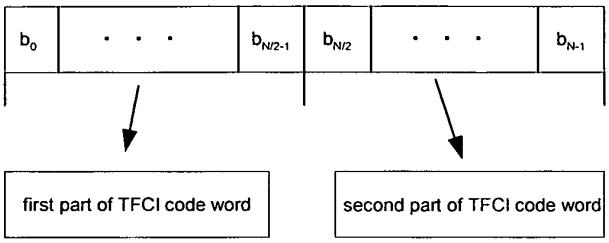


Figure 8: Mapping of TFCI code word bits to timeslot

The locations of the first and second parts of the TFCI code word in the timeslot is defined in [7].

If the shortest transmission time interval of any constituent TrCH is at least 20 ms the successive TFCI code words in the frames in the TTI shall be identical. If TFCI is transmitted on multiple timeslots in a frame each timeslot shall have the same TFCI code word.

4.3.2 Coding and Bit Scrambling of the Paging Indicator

The paging indicator P_q, $q = 0, ..., N_{PI}-1$, $P_q \in \{0, 1\}$ is an identifier to instruct the UE whether there is a paging message for the groups of mobiles that are associated to the PI, calculated by higher layers, and the associated paging indicator P_q. The length L_{PI} of the paging indicator is $L_{PI}=2$, $L_{PI}=4$ or $L_{PI}=8$ symbols. $N_{PIB} = 2*N_{PI}*L_{PI}$ bits are used for the paging indicator transmission in one radio frame. The mapping of the paging indicators to the bits e_i, $i = 1, ..., N_{PIB}$ is shown in table 10.

Table 10: Mapping of the paging indicator

P_q	Bits $\{e_{2Lpi*q+1}, e_{2Lpi*q+2}, \ldots, e_{2Lpi*(q+1)}\}$	Meaning
0	{0, 0, ..., 0}	There is no necessity to receive the PCH
1	{1, 1, ..., 1}	There is the necessity to receive the PCH

If the number S of bits in one radio frame available for the PICH is bigger than the number N_{PIB} of bits used for the transmission of paging indicators, the sequence $e = \{e_1, e_2, ..., e_{NPIB}\}$ is extended by S-N_{PIB} bits that are set to zero, resulting in a sequence $h = \{h_1, h_2, ..., h_S\}$:

$$h_k = e_k, \quad k = 1, ..., N_{PIB}$$
$$h_k = 0, \quad k = N_{PIB} + 1, ..., S$$

The bits h_k , $k = 1, ..., S$ on the PICH then undergo bit scrambling as defined in section 4.2.9.

The bits s_k, $k = 1, ..., S$ output from the bit scrambler are then transmitted over the air as shown in [7].

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4.4 Coding for layer 1 control for the 1.28 Mcps option

4.4.1 Coding of transport format combination indicator (TFCI) for QPSK

The coding of TFCI for 1.28Mcps TDD is same as that of 3.84Mcps TDD.cf.[4.3.1 'Coding of transport format combination indicator'].

4.4.1.1 Mapping of TFCI code word

Denote the number of bits in the TFCI code word by $N_{TFCI\ code\ word}$, and denote the TFCI code word bits by b_k, where k = 0, ..., $N_{TFCI\ code\ word}$ -1

When the number of bits in the TFCI code word is 8, 16, 32, the mapping of the TFCI code word to the TFCI bit positions shall be as follows:

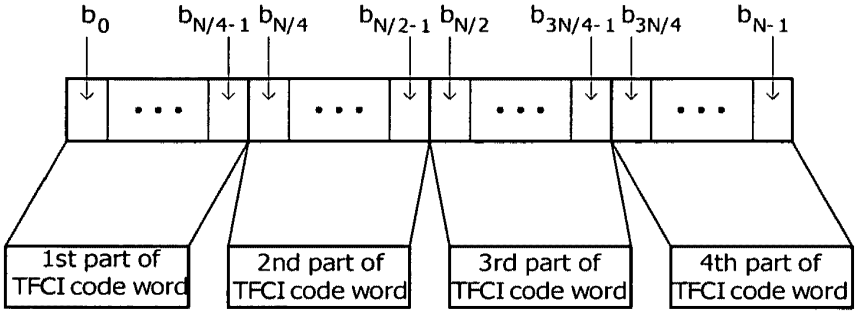


Figure 9: Mapping of TFCI code word bits to TFCI position in 1.28 Mcps TDD option, where N = $N_{TFCI\ code\ word}$.

When the number of bits of the TFCI code word is 4 , then the TFCI code word is equally divided into two parts for the consecutive two subframe and mapped onto the end of the first data field in each of the consecutive subframes.The mapping for $N_{TFCI\ code\ word}$ =4 is shown in figure 10:

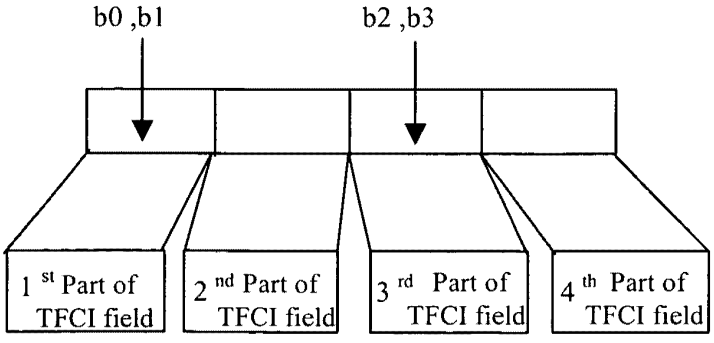


Figure 10: Mapping of TFCI code word bits to TFCI position in 1.28 Mcps TDD option, when $N_{TFCI\ code\ word.}$=4

The location of the 1st to 4th parts of the TFCI code word in the timeslot is defined in [7].

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If the shortest transmission time interval of any constituent TrCH is at least 20 ms, then successive TFCI code words in the frames within the TTI shall be identical. If a TFCI is transmitted on multiple timeslots in a frame each timeslot shall have the same TFCI code word.

4.4.2 Coding of transport format combination indicator (TFCI) for 8PSK

Encoding of TFCI bits depends on the number of them and the modulation in use. When 2 Mcps service is transmitted, 8PSK modulation is applied in 1.28 Mcps TDD option. The encoding scheme for TFCI when the number of bits are 6 – 10, and less than 6 bits is described in section 4.4.2.1 and 4.4.2.2, respectively.

4.4.2.1 Coding of long TFCI lengths

When the number of TFCI bits is 6 – 10, the TFCI bits are encoded by using a (64,10) sub-code of the second order Reed-Muller code, then 16 bits out of 64 bits are punctured (Puncturing positions are 0, 4, 8, 13, 16, 20, 27, 31, 34, 38, 41, 44, 50, 54, 57, 61st bits). The coding procedure is shown in Figure 11.

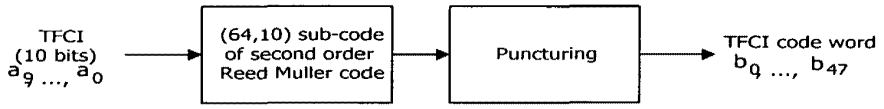


Figure 11: Channel coding of long TFCI bits for 8PSK

If the TFCI consists of less than 10 bits, it is padded with zeros to 10 bits, by setting the most significant bits to zero. The code words of the punctured (48,10) sub-code of the second order Reed-Muller codes are linear combination of 10 basis sequences. The basis sequences are shown in Table 11.

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Table 11: Basis sequences for (48,10) TFCI code

I	$M_{I,0}$	$M_{I,1}$	$M_{I,2}$	$M_{I,3}$	$M_{I,4}$	$M_{I,5}$	$M_{I,6}$	$M_{I,7}$	$M_{I,8}$	$M_{I,9}$
0	1	0	0	0	0	0	1	0	1	0
1	0	1	0	0	0	0	1	1	0	0
2	1	1	0	0	0	0	1	1	0	1
3	1	0	1	0	0	0	1	1	1	0
4	0	1	1	0	0	0	1	0	1	0
5	1	1	1	0	0	0	1	1	1	0
6	1	0	0	1	0	0	1	1	1	1
7	0	1	0	1	0	0	1	1	0	1
8	1	1	0	1	0	0	1	0	1	0
9	0	0	1	1	0	0	1	1	0	0
10	0	1	1	1	0	0	1	1	0	1
11	1	1	1	1	0	0	1	1	1	1
12	1	0	0	0	1	0	1	0	1	1
13	0	1	0	0	1	0	1	1	1	0
14	1	1	0	0	1	0	1	0	0	1
15	1	0	1	0	1	0	1	0	1	1
16	0	1	1	0	1	0	1	1	0	0
17	1	1	1	0	1	0	1	1	1	0
18	0	0	0	1	1	0	1	0	0	1
19	1	0	0	1	1	0	1	0	1	1
20	0	1	0	1	1	0	1	0	1	0
21	0	0	1	1	1	0	1	0	1	0
22	1	0	1	1	1	0	1	1	0	1
23	0	1	1	1	1	0	1	1	1	0
24	0	0	0	0	0	1	1	1	0	1
25	1	0	0	0	0	1	1	1	1	0
26	1	1	0	0	0	1	1	1	1	1
27	0	0	1	0	0	1	1	0	1	1
28	1	0	1	0	0	1	1	1	0	1
29	1	1	1	0	0	1	1	0	1	1
30	0	0	0	1	0	1	1	0	0	1
31	0	1	0	1	0	1	1	0	0	1
32	1	1	0	1	0	1	1	1	1	1
33	1	0	1	1	0	1	1	0	0	1
34	0	1	1	1	0	1	1	1	1	0
35	1	1	1	1	0	1	1	1	0	1
36	0	0	0	0	1	1	1	1	1	0
37	1	0	0	0	1	1	1	0	1	1
38	1	1	0	0	1	1	1	1	1	1
39	0	0	1	0	1	1	1	1	0	0
40	1	0	1	0	1	1	1	1	0	0
41	1	1	1	0	1	1	1	1	1	1
42	0	0	0	1	1	1	1	1	1	1
43	0	1	0	1	1	1	1	0	1	0
44	1	1	0	1	1	1	1	0	1	0
45	0	0	1	1	1	1	1	0	1	1
46	0	1	1	1	1	1	1	0	0	1
47	1	1	1	1	1	1	1	1	0	0

Let's define the TFCI bits as a_0 , a_1 , a_2 , a_3 , a_4 , a_5 , a_6 , a_7 , a_8 , a_9, where a_0 is the LSB and a_9 is the MSB. The TFCI bits shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated radio frame.

The output TFCI code word bits b_i are given by:

$$b_i = \sum_{n=0}^{9} (a_n \times M_{i,n}) \bmod 2$$

where i=0...47. $N_{TFCI\ code\ word}$=48.

4.4.2.2 Coding of short TFCI lengths

4.4.2.2.1 Coding very short TFCIs by repetition

When the number of TFCI bits is 1 or 2, then repetition will be used for the coding. In this case, each bit is repeated to a total of 6 times giving 6-bit transmission ($N_{TFCI\ code\ word}$ = 6) for a single TFCI bit and 12-bit transmission ($N_{TFCI\ code\ word}$ = 12) for 2 TFCI bits. The TFCI bit(s) a_0 (or a_0 and a_1 where a_0 is the LSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated radio frame.

In the case of $N_{TFCI\ code\ word}$=6, the TFCI codeword $\{b_0, b_1, b_2, b_3, b_4, b_5\}$ is equal to the sequence $\{a_0, a_0, a_0, a_0, a_0, a_0\}$.

In the case of $N_{TFCI\ code\ word}$=12, the TFCI codeword $\{b_0, b_1, \ldots, b_{11}\}$ is equal to the sequence $\{a_0, a_1, a_0, a_1, a_0, a_1, a_0, a_1, a_0, a_1, a_0, a_1\}$.

4.4.2.2.2 Coding short TFCIs using bi-orthogonal codes

If the number of TFCI bits is in the range of 3 to 5, the TFCI bits are encoded using a (32,5) first order Reed-Muller code, then 8 bits out of 32 bits are punctured (Puncturing positions are 0, 1, 2, 3, 4, 5, 6, 7th bits). The coding procedure is shown in Figure 12.

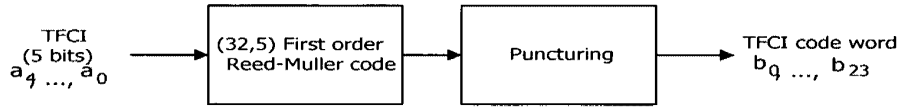


Figure 12: Channel coding of short TFCI bits for 8PSK

If the TFCI consists of less than 5 bits, it is padded with zeros to 5 bits, by setting the most significant bits to zero. The code words of the punctured (32,5) first order Reed-Muller codes are linear combination of 5 basis sequences shown in Table 12.

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Table 12: Basis sequences for (24,5) TFCI code

I	$M_{i,0}$	$M_{i,1}$	$M_{i,2}$	$M_{i,3}$	$M_{i,4}$
0	0	0	0	1	0
1	1	0	0	1	0
2	0	1	0	1	0
3	1	1	0	1	0
4	0	0	1	1	0
5	1	0	1	1	0
6	0	1	1	1	0
7	1	1	1	1	0
8	0	0	0	0	1
9	1	0	0	0	1
10	0	1	0	0	1
11	1	1	0	0	1
12	0	0	1	0	1
13	1	0	1	0	1
14	0	1	1	0	1
15	1	1	1	0	1
16	0	0	0	1	1
17	1	0	0	1	1
18	0	1	0	1	1
19	1	1	0	1	1
20	0	0	1	1	1
21	1	0	1	1	1
22	0	1	1	1	1
23	1	1	1	1	1

Let's define the TFCI bits as a_0 , a_1 , a_2 , a_3 , a_4, where a_0 is the LSB and a_4 is the MSB. The TFCI bits shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated radio frame.

The output code word bits b_i are given by:

$$b_i = \sum_{n=0}^{4} (a_n \times M_{i,n}) \bmod 2$$

where i=0...23. $N_{TFCI\ code\ word}$=24.

4.4.2.3 Mapping of TFCI code word

Denote the number of bits in the TFCI code word by $N_{TFCI\ code\ word}$, and denote the TFCI code word bits by b_k, where k = 0, ..., $N_{TFCI\ code\ word}$-1.

When the number of bits in the TFCI code word is 12, 24 or 48, the mapping of the TFCI code word to the TFCI bit positions in a time slot shall be as follows.

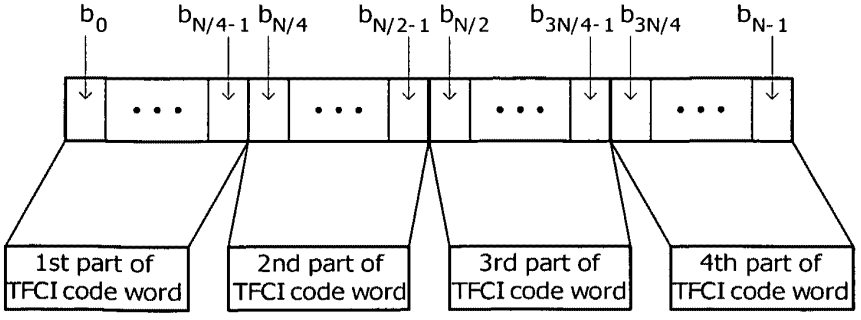


Figure 13: Mapping of TFCI code word bits to timeslot in 1.28 Mcps TDD option, where N = $N_{TFCI\ code\ word}$.

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When the number of bits in the TFCI code word is 6, the TFCI code word is equally divided into two parts for the consecutive two sub-frames and mapped onto the first data field in each of the consecutive sub-frames. The mapping of the TFCI code word to the TFCI bit positions in a time slot shall be as shown in figure 14.

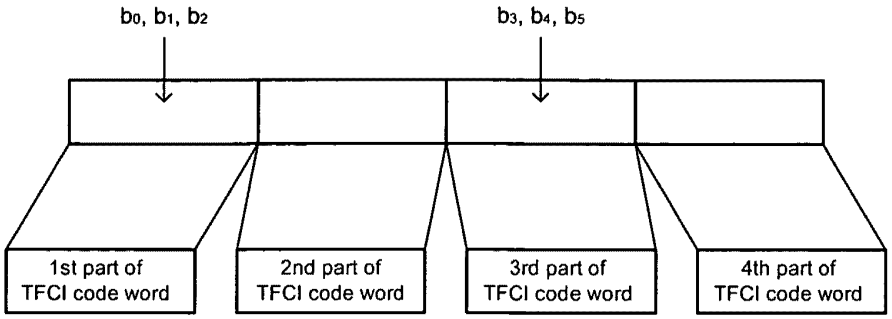


Figure 14: Mapping of TFCI code word bits to timeslot in 1.28 Mcps TDD option when $N_{TFCI\ code\ word} = 6$

The location of the 1st to 4th parts of the TFCI code word in the timeslot is defined in [7].

4.4.3 Coding and Bit Scrambling of the Paging Indicator

The paging indicator P_q, $q = 0, ..., N_{PI}-1$, $P_q \in \{0, 1\}$ is an identifier to instruct the UE whether there is a paging message for the groups of mobiles that are associated to the PI, calculated by higher layers, and the associated paging indicator P_q. The length L_{PI} of the paging indicator is $L_{PI}=2$, $L_{PI}=4$ or $L_{PI}=8$ symbols. $N_{PIB} = 2*N_{PI}*L_{PI}$ bits are used for the paging indicator transmission in one radio frame. The mapping of the paging indicators to the bits e_i, $i = 1, ..., N_{PIB}$ is shown in table 13.

Table 13: Mapping of the paging indicator

P_q	Bits $\{e_{2L_{PI}*q+1}, e_{2L_{PI}*q+2}, ..., e_{2L_{PI}*(q+1)}\}$	Meaning
0	{0, 0, ..., 0}	There is no necessity to receive the PCH
1	{1, 1, ..., 1}	There is the necessity to receive the PCH

If the number S of bits in one radio frame available for the PICH is bigger than the number N_{PIB} of bits used for the transmission of paging indicators, the sequence $e = \{e_1, e_2, ..., e_{NPIB}\}$ is extended by S-N_{PIB} bits that are set to zero, resulting in a sequence $h = \{h_1, h_2, ..., h_S\}$:

$$h_k = e_k, \quad k = 1, ..., N_{PIB}$$
$$h_k = 0, \quad k = N_{PIB}+1, ..., S$$

The bits h_k, $k = 1, ..., S$ on the PICH then undergo bit scrambling as defined in section 4.2.9.

The bits s_k, $k = 1, ..., S$ output from the bit scrambler are then transmitted over the air as shown in [7].

4.4.4 Coding of the Fast Physical Access Channel (FPACH) information bits

The FPACH burst is composed by 32 information bits which are block coded and convolutional coded, and then delivered in one sub-frame as follows:

1. The 32 information bits are protected by 8 parity bits for error detection as described in sub-clause 4.2.1.1.
2. Convolutional code with constraint length 9 and coding rate ½ is applied as described in sub-clause 4.2.3.1. The size of data block c(k) after convolutional encoder is 96 bits.
3. To adjust the size of the data block c(k) to the size of the FPACH burst, 8 bits are punctured as described in sub-clause 4.2.7 with the following clarifications:

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- $N_{i,j}$=96 is the number of bits in a radio sub-frame before rate matching
- $\Delta N_{i,j}$ = -8 is the number of bits to punctured in a radio sub-frame
- $e_{ini} = a \times N_{ij}$

The 88 bits after rate matching are then delivered to the intra-frame interleaving.

4. The bits in input to the interleaving unit are denoted as {x(0), ..., x(87)}. The coded bits are block rectangular interleaved according to the following rule: the input is written row by row, the output is read column by column.

$$\begin{bmatrix} x(0) & x(1) & x(2) & \dots & x(7) \\ x(8) & x(9) & x(10) & \dots & x(15) \\ \vdots & \vdots & \vdots & \dots & \vdots \\ x(80) & x(81) & x(82) & \dots & x(87) \end{bmatrix}$$

Hence, the interleaved sequence is denoted by y (i) and are given by:

y(0), y(1), ..., y(87)=x(0), x(8), ...,x(80),x(1), ..., x(87).

4.5 Coding for HS-DSCH

Figure 15 illustrates the overall concept of transport-channel coding for HS-DSCH. Data arrives at the coding unit in the form of one transport block once every TTI. The TTI is 5 ms for 1.28 Mcps TDD and 10 ms for 3.84 Mcps TDD.

The following coding steps for HS-DSCH can be identified:

- add CRC to each transport block (see subclause 4.5.1);
- code block segmentation (see subclause 4.5.2);
- channel coding (see subclause 4.5.3);
- hybrid ARQ (see subclause 4.5.4);
- bit scrambling (see subclause 4.5.5);
- interleaving for HS-DSCH (see subclause 4.5.6);
- constellation re-arrangement for 16QAM (see subclause 4.5.7);
- mapping to physical channels (see subclause 4.5.8).

The coding steps for HS-DSCH are shown in figure 15.

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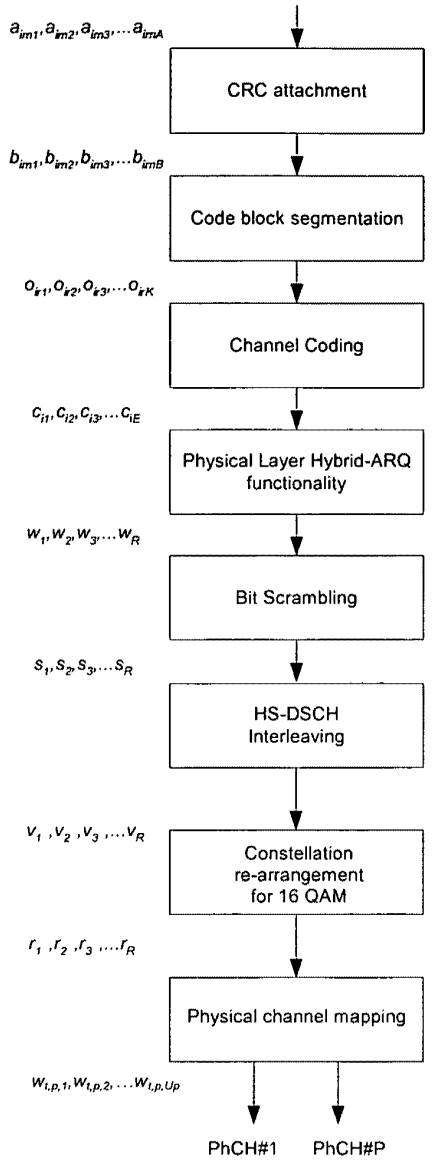


Figure 15. Coding chain for HS-DSCH

In the following the number of transport blocks is always one. When referencing non HS-DSCH formulae which are used in correspondence with HS-DSCH formulae the convention is used that transport block subscripts may be omitted (e.g. X_i when i is always 1 may be written X).

4.5.1 CRC attachment for HS-DSCH

A CRC of size 24 bits is calculated and added per HS-DSCH TTI. The CRC polynomial is defined in 4.2.1.1 with the following specific parameters: $i = 1$, $L_1 = 24$ bits.

4.5.2 Code block segmentation for HS-DSCH

Code block segmentation for the HS-DSCH transport channel shall be done with the general method described in 4.2.2.2 above with the following specific parameters.

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There will only be one transport block, $i = 1$. The bits b_{im1}, b_{im2}, b_{im3},...b_{imB} input to the block are mapped to the bits x_{i1}, x_{i2}, x_{i3},....x_{iXI} directly. It follows that $X_I = B$. Note that the bits x referenced here refer only to the internals of the code block segmentation function. The output bits from the code block segmentation function are o_{ir1}, o_{ir2}, o_{ir3},...o_{irK}.

The value of Z = 5114 for turbo coding shall be used.

4.5.3 Channel coding for HS-DSCH

Channel coding for the HS-DSCH transport channel shall be done with the general method described in 4.2.3 above with the following specific parameters.

There will be a maximum of one transport block, $i = 1$. The rate 1/3 turbo coding shall be used.

4.5.4 Hybrid ARQ for HS-DSCH

The hybrid ARQ functionality matches the number of bits at the output of the channel coder to the total number of bits of the HS-PDSCH set to which the HS-DSCH is mapped. The hybrid ARQ functionality is controlled by the redundancy version (RV) parameters. The exact set of bits at the output of the hybrid ARQ functionality depends on the number of input bits, the number of output bits, and the RV parameters.

The hybrid ARQ functionality consists of two rate-matching stages and a virtual buffer as shown in the figure below.

The first rate matching stage matches the number of input bits to the virtual IR buffer, information about which is provided by higher layers. Note that, if the number of input bits does not exceed the virtual IR buffering capability, the first rate-matching stage is transparent.

The second rate matching stage matches the number of bits after first rate matching stage to the number of physical channel bits available in the HS-PDSCH set in the TTI.

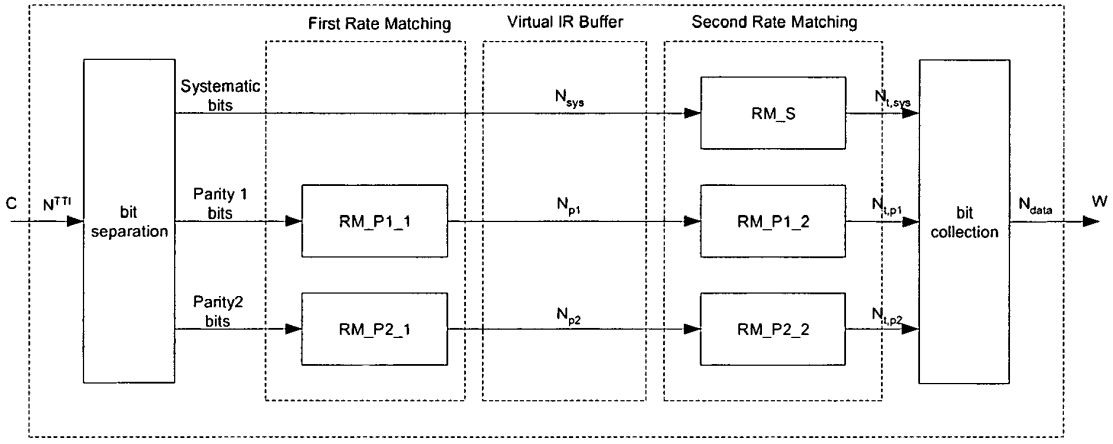


Figure 16: HS-DSCH hybrid ARQ functionality

4.5.4.1 HARQ bit separation

The HARQ bit separation function shall be performed in the same way as bit separation for turbo encoded TrCHs in 4.2.7.2 above.

4.5.4.2 HARQ First Rate Matching Stage

HARQ first stage rate matching for the HS-DSCH transport channel shall be done with the general method described in 4.2.7.1.2 above with the following specific parameters.

The maximum number of soft channel bits available in the virtual IR buffer is N_{IR} which is signalled from higher layers for each HARQ process. The number of coded bits in a TTI before rate matching is N^{TTI} this is deduced from

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information signalled from higher layers and parameters signalled on the HS-SCCH for each TTI. Note that HARQ processing and physical layer storage occurs independently for each HARQ process currently active.

If N_{IR} is greater than or equal to N^{TTI} (i.e. all coded bits of the corresponding TTI can be stored) the first rate matching stage shall be transparent. This can, for example, be achieved by setting $e_{minus} = 0$. Note that no repetition is performed.

If N_{IR} is smaller than N^{TTI} the parity bit streams are punctured as in 4.2.7.1.2 above by setting the rate matching parameter $\Delta N_{il}^{TTI} = N_{IR} - N^{TTI}$ where the subscripts i and l refer to transport channel and transport format in the referenced sub-clause. Note the negative value is expected when the rate matching implements puncturing. Bits selected for puncturing which appear as δ in the algorithm in 4.2.7 above shall be discarded and not counted in the totals for the streams through the virtual IR buffer.

4.5.4.3 HARQ Second Rate Matching Stage

HARQ second stage rate matching for the HS-DSCH transport channel shall be done with the general method described in 4.2.7.3 above with the following specific parameters. Bits selected for puncturing which appear as δ in the algorithm in 4.2.7.3 above shall be discarded and are not counted in the streams towards the bit collection.

The parameters of the second rate matching stage depend on the value of the RV parameters s and r. The parameter s can take the value 0 or 1 to distinguish between transmissions that prioritise systematic bits (s = 1) and non systematic bits (s = 0). The parameter r (range 0 to r_{max}-1) changes the initial error variable e_{ini} in the case of puncturing. In case of repetition both parameters r and s change the initial error variable e_{ini}. The parameters X_i, e_{plus} and e_{minus} are calculated as per table 14below.

Denote the number of bits before second rate matching as N_{sys} for the systematic bits, N_{p1} for the parity 1 bits, and N_{p2} for the parity 2 bits, respectively. For the HS-DSCH, denote the number of timeslots used as T, the number of codes per timeslot as C and the number of bits available in timeslot t as U_t, where $U_t = C \times N_{Data/Slot}$ and $N_{Data/Slot}$ is as defined in [7] for timeslot t. N_{data} is the number of bits available to the HS-DSCH in one TTI and is defined as $N_{data} = \sum_{t=1}^{T} U_t$.

The rate matching parameters are determined as follows.

For $N_{data} \le N_{sys} + N_{p1} + N_{p2}$, puncturing is performed in the second rate matching stage. The number of transmitted systematic bits in a transmission is $N_{t,sys} = \min\{N_{sys}, N_{data}\}$ for a transmission that prioritises systematic bits and $N_{t,sys} = \max\{N_{data} - (N_{p1} + N_{p2}), 0\}$ for a transmission that prioritises non systematic bits.

For $N_{data} > N_{sys} + N_{p1} + N_{p2}$ repetition is performed in the second rate matching stage. A similar repetition rate in all bit streams is achieved by setting the number of transmitted systematic bits to $N_{t,sys} = \left\lfloor N_{sys} \cdot \frac{N_{data}}{N_{sys} + 2N_{p1}} \right\rfloor$.

The number of parity bits in a transmission is: $N_{t,p1} = \left\lfloor \frac{N_{data} - N_{t,sys}}{2} \right\rfloor$ and $N_{t,p2} = \left\lceil \frac{N_{data} - N_{t,sys}}{2} \right\rceil$ for the parity 1 and parity 2 bits, respectively.

Table 14 below summarizes the resulting parameter choice for the second rate matching stage.

Table 14: Parameters for HARQ second rate matching

	X_i	e_{plus}	e_{minus}
Systematic RM S	N_{sys}	N_{sys}	$\lvert N_{sys} - N_{t,sys} \rvert$
Parity 1 RM P1_2	N_{p1}	$2 \cdot N_{p1}$	$2 \cdot \lvert N_{p1} - N_{t,p1} \rvert$
Parity 2 RM P2_2	N_{p2}	N_{p2}	$\lvert N_{p2} - N_{t,p2} \rvert$

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The rate matching parameter e_{ini} is calculated for each bit stream according to the RV parameters r and s using

$e_{ini}(r) = \{(X_i - \lfloor r \cdot e_{plus} / r_{\max} \rfloor - 1) \bmod e_{plus}\} + 1$ in the case of puncturing, i.e., $N_{data} \le N_{sys} + N_{p1} + N_{p2}$, and

$e_{ini}(r) = \{(X_i - \lfloor (s + 2 \cdot r) \cdot e_{plus} / (2 \cdot r_{\max}) \rfloor - 1) \bmod e_{plus}\} + 1$ for repetition, i.e.,

$N_{data} > N_{sys} + N_{p1} + N_{p2}$. Where $r \in \{0, 1, \cdots, r_{\max} - 1\}$ and $r_{\max}$ is the total number of redundancy versions allowed by varying r as defined in 4.6.1.4. Note that r_{max} varies depending on the modulation mode, i.e. for 16QAM $r_{max} = 2$ and for QPSK $r_{max} = 4$.

Note: For the modulo operation the following clarification is used: the value of (x mod y) is strictly in the range of 0 to y-1 (i.e. -1 mod 10 = 9).

4.5.4.4 HARQ bit collection

The HARQ bit collection is achieved using a rectangular interleaver of size $N_{row} \times N_{col}$.

The number of rows and columns are determined from:

$$N_{row} = 4 \text{ for 16QAM and } N_{row} = 2 \text{ for QPSK}$$

$$N_{col} = N_{data} / N_{row}$$

where N_{data} is used as defined in 4.5.4.3 above.

Data is written into the interleaver column by column, and read out of the interleaver column by column, starting from the first column.

$N_{t,sys}$ is the number of transmitted systematic bits. Intermediate values N_r and N_c are calculated using:

$$N_r = \left\lfloor \frac{N_{t,sys}}{N_{col}} \right\rfloor \text{ and } N_c = N_{t,sys} - N_r \cdot N_{col}.$$

If $N_c = 0$ and $N_r > 0$, the systematic bits are written into rows $1 \ldots N_r$.

Otherwise systematic bits are written into rows $1 \ldots N_r + 1$ in the first N_c columns and, if $N_r > 0$, also into rows $1 \ldots N_r$ in the remaining N_{col}-N_c columns.

The remaining space is filled with parity bits. The parity bits are written column wise into the remaining rows of the respective columns. Parity 1 and 2 bits are written in alternating order, starting with a parity 2 bit in the first available column with the lowest index number.

In the case of 16QAM for each column the bits are read out of the interleaver in the order row 1, row 2, row 3, row 4. In the case of QPSK for each column the bits are read out of the interleaver in the order row1, row2.

4.5.5 Bit scrambling

The bit scrambling for HS-DSCH shall be done with the general method described in subclause 4.2.9.

4.5.6 Interleaving for HS-DSCH

The interleaving for TDD is done over all bits in the TTI, as shown in figure 17 when QPSK modulation is being used for the HS-DSCH, and figure 18 when 16-QAM modulation is being used. The bits input to the block interleaver are denoted by $s_1, s_2, s_3, \ldots, s_R$, where R is the number of bits in one TTI.

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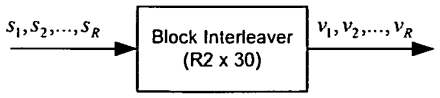


Figure 17: Interleaver structure for HS-DSCH with QPSK modulation

For QPSK, the interleaver is a block interleaver and consists of bits input to a matrix with padding, the inter-column permutation for the matrix and bits output from the matrix with pruning. The output bit sequence from the block interleaver is derived as follows:

(1) The number of columns of the matrix is 30. The columns of the matrix are numbered 0, 1, 2, ..., 29 from left to right.

(2) Determine the number of rows of the matrix, $R2$, by finding minimum integer $R2$ such that $R \leq 30 \times R2$. The rows of rectangular matrix are numbered 0, 1, 2, ..., $R2 - 1$ from top to bottom.

(3) Write the input bit sequence $s_1, s_2, s_3, \ldots, s_R$ into the $R2 \times 30$ matrix row by row starting with bit y_1 in column 0 of row 0:

$$\begin{bmatrix} y_1 & y_2 & y_3 & \cdots & y_{30} \\ y_{31} & y_{32} & y_{33} & \cdots & y_{60} \\ \vdots & \vdots & \vdots & & \vdots \\ y_{30\cdot(R2-1)+1} & y_{30\cdot(R2-1)+2} & y_{30\cdot(R2-1)+3} & \cdots & y_{30\cdot R2} \end{bmatrix}$$

where $y_k = s_k$ for $k = 1, 2, \ldots, R$ and, if $R < 30 \times R2$, dummy bits are inserted for $k = R+1, R+2, \ldots, 30 \times R2$. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

(4) Perform the inter-column permutation for the matrix based on the pattern $\langle P2(j) \rangle_{j \in \{0,1,\ldots,29\}}$ that is shown in Table 7, where P2(j) is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by y'_k.

$$\begin{bmatrix} y'_1 & y'_{R2+1} & y'_{2\cdot R2+1} & \cdots & y'_{29\cdot R2+1} \\ y'_2 & y'_{R2+2} & y'_{2\cdot R2+2} & \cdots & y'_{29\cdot R2+2} \\ \vdots & \vdots & \vdots & & \vdots \\ y'_{R2} & y'_{2\cdot R2} & y'_{3\cdot R2} & \cdots & y'_{30\cdot R2} \end{bmatrix}$$

(5) The output of the block interleaver is the bit sequence read out column by column from the inter-column permuted $R2 \times 30$ matrix. The output is pruned by deleting dummy bits that were padded to the input of the matrix before the inter-column permutation, i.e. bits y'_k that corresponds to bits y_k with $k > R$ are removed from the output. The bits after interleaving are denoted by $v_1, v_2, v_3, \ldots, v_R$, where v_1 corresponds to the bit y'_k with smallest index k after pruning, v_2 to the bit y'_k with second smallest index k after pruning, and so on.

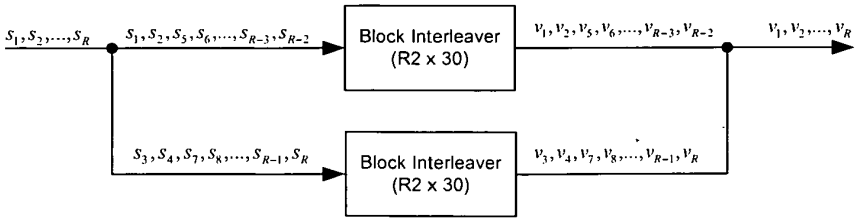


Figure 18: Interleaver structure for HS-DSCH with 16-QAM modulation

For 16QAM, a second identical interleaver operates in parallel to the first. For both interleavers, $R2$ is chosen to be the minimum integer that satisfies $R \leq 60 \times R2$. The output bits from the bit scrambling operation are divided pairwise between the interleavers: bits s_k and s_{k+1} go to the first interleaver and bits s_{k+2} and s_{k+3} go to the second interleaver,

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where k mod 4 = 1. Bits are collected pairwise from the interleavers: bits v_k and v_{k+1} are obtained from the first interleaver and bits v_{k+2} and v_{k+3} are obtained from the second interleaver, where again k mod 4 = 1.

4.5.7 Constellation re-arrangement for 16 QAM

This function only applies to 16 QAM modulated bits. In case of QPSK it is transparent.

The following table 15 describes the operations that produce the different rearrangements.

The bits of the input sequence are mapped in groups of 4 so that v_k, v_{k+1}, v_{k+2}, v_{k+3} are used, where k mod 4 = 1.

Table 15: Constellation re-arrangement for 16 QAM

Constellation version parameter *b*	Output bit sequence	Operation
0	$v_k v_{k+1} v_{k+2} v_{k+3}$	None
1	$v_{k+2} v_{k+3} v_k v_{k+1}$	Swapping MSBs with LSBs
2	$v_k v_{k+1} \overline{v_{k+2}} \overline{v_{k+3}}$	Inversion of the logical values of LSBs
3	$v_{k+2} v_{k+3} \overline{v_k} \overline{v_{k+1}}$	Swapping MSBs with LSBs, and inversion of the logical values of LSBs

The output bit sequences from the table above map to the output bits in groups of 4, i.e. r_k, r_{k+1}, r_{k+2}, r_{k+3}, where k mod 4 = 1.

4.5.8 Physical channel mapping for HS-DSCH

The HS-PDSCH is defined in [7]. The bits input to the physical channel mapping are denoted by $r_1, r_2, ..., r_R$, where R is the number of physical channel bits in the allocation for the current TTI. These bits are mapped to the physical channel bits, $\{w_{t,p,j} : t = 1, 2, ..., T; p = 1, 2, ..., C; j = 1, 2, ..., U_t\}$, where t is the timeslot index, T is the number of timeslots in the allocation message, p is the physical channel index, C is the number of codes per timeslot in the allocation message, j is the physical channel bit index and U_t is the number of bits per physical channel in timeslot t. The timeslot index, t, increases with increasing timeslot number; the physical channel index, p, increases with increasing channelisation code index, and the physical channel bit index, j, increases with increasing physical channel bit position in time.

The bits r_k shall be mapped to the PhCHs according to the following rule :

Define $\{y_{t,k} : k = 1, 2, ..., C \cdot U_t\}$ to be the set of bits to be transmitted in timeslot t as follows :

$y_{1,k} = r_k$ for $k = 1, 2, ..., C \cdot U_1$

$y_{2,k} = r_{k+C \cdot U_1}$ for $k = 1, 2, ..., C \cdot U_2$

...

$y_{T,k} = r_{k+C\sum_{t=1}^{T-1} U_t}$ for $k = 1, 2, ..., C \cdot U_T$

When the modulation level applied to the physical channels is 16- QAM :

The physical channel p used to transmit the kth bit in the sequence $y_{t,k}$ is :

$$p = \left\lfloor \frac{k-1}{4} \right\rfloor \bmod C + 1$$

If p is odd then :

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$$w_{t,p,j} = y_{t,k} \quad \text{where } j = 4 \cdot \left\lfloor \frac{k-1}{4 \cdot C} \right\rfloor + (k-1) \bmod 4 + 1$$

If p is even then :

$$w_{t,p,j} = y_{t,k} \quad \text{where } j = U_t - 4 \cdot \left\lfloor \frac{k-1}{4 \cdot C} \right\rfloor - 3 + (k-1) \bmod 4$$

Otherwise, when the modulation level applied to the physical channels is QPSK :

The physical channel p used to transmit the kth bit in the sequence $y_{t,k}$ is :

$$p = (k-1) \bmod C + 1$$

If p is odd then :

$$w_{t,p,j} = y_{t,k} \text{ where } \quad j = \left\lfloor \frac{k-1}{C} \right\rfloor + 1$$

If p is even then :

$$w_{t,p,j} = y_{t,k} \text{ where } j = U_t - \left\lfloor \frac{k-1}{C} \right\rfloor$$

4.6 Coding/Multiplexing for HS-SCCH

The following information, provided by higher layers, is transmitted by means of the HS-SCCH physical channel.

- Channelisation-code-set information (8 bits): $x_{ccs,1}, x_{ccs,2}, \ldots, x_{ccs,8}$
- Time slot information (n bits where n = 5 for 1.28 Mcps TDD and n = 13 for 3.84 Mcps TDD): $x_{ts,1}, x_{ts,2}, \ldots, x_{ts,n}$
- Modulation scheme information (1 bit): $x_{ms,1}$
- Transport-block size information (m bits where m = 6 for 1.28 Mcps TDD and m = 9 for 3.84 Mcps TDD): $x_{tbs,1}, x_{tbs,2}, \ldots, x_{tbs,m}$
- Hybrid-ARQ process information (3 bits): $x_{hap,1}, x_{hap,2}, x_{hap,3}$
- Redundancy version information (3 bits): $x_{rv,1}, x_{rv,2}, x_{rv,3}$
- New data indicator (1 bit): $x_{nd,1}$
- HS-SCCH cyclic sequence number (3 bits): $x_{hcsn,1}, x_{hcsn,2}, x_{hcsn,3}$
- UE identity (16 bits): $x_{ue,1}, x_{ue,2}, \ldots, x_{ue,16}$

The following coding/multiplexing steps can be identified:

- multiplexing of HS-SCCH information (see subclause 4.6.2)
- CRC attachment (see subclause 4.6.3);
- channel coding (see subclause 4.6.4);
- rate matching (see subclause 4.6.5);
- interleaving for HS-SCCH (see subclause 4.6.6);

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- mapping to physical channels (see subclauses 4.6.7 and 4.6.8).

The general coding/multiplexing flow is shown in Figure 19.

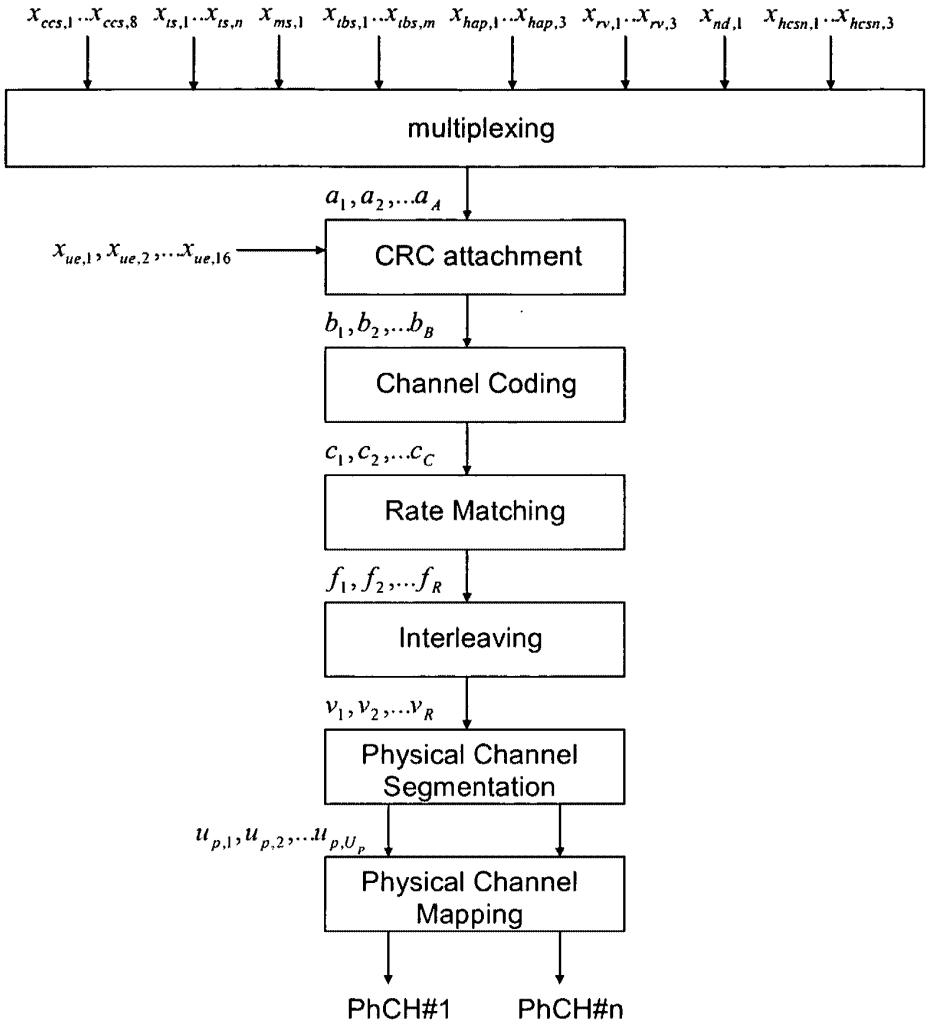


Figure 19 Coding and Multiplexing for HS-SCCH

4.6.1 HS-SCCH information field mapping

4.6.1.1 Channelisation code set information mapping

HS-PDSCH channelisation codes are allocated contiguously from a signalled start code to a signalled stop code, and the allocation includes both the start and stop code. The start code k_{start} is signalled by the bits $x_{ccs,1}$, $x_{ccs,2}$, $x_{ccs,3}$, $x_{ccs,4}$ and the stop code k_{stop} by the bits $x_{ccs,5}$, $x_{ccs,6}$, $x_{ccs,7}$, $x_{ccs,8}$. The mapping in Table 16 below applies.

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Table 16: Channelisation code set information mapping

k_{start}	$x_{ccs,1}$	$x_{ccs,2}$	$x_{ccs,3}$	$x_{ccs,4}$	k_{stop}	$x_{ccs,5}$	$x_{ccs,6}$	$x_{ccs,7}$	$x_{ccs,8}$
1	0	0	0	0	1	0	0	0	0
2	0	0	0	1	2	0	0	0	1
3	0	0	1	0	3	0	0	1	0
4	0	0	1	1	4	0	0	1	1
5	0	1	0	0	5	0	1	0	0
6	0	1	0	1	6	0	1	0	1
7	0	1	1	0	7	0	1	1	0
8	0	1	1	1	8	0	1	1	1
9	1	0	0	0	9	1	0	0	0
10	1	0	0	1	10	1	0	0	1
11	1	0	1	0	11	1	0	1	0
12	1	0	1	1	12	1	0	1	1
13	1	1	0	0	13	1	1	0	0
14	1	1	0	1	14	1	1	0	1
15	1	1	1	0	15	1	1	1	0
16	1	1	1	1	16	1	1	1	1

If a value of $k_{start} = 16$ and $k_{stop} = 1$ is signalled, a spreading factor of SF=1 shall be used for the HS-PDSCH resources. Other than this case, $k_{start} > k_{stop}$ shall be treated as an error by the UE.

4.6.1.2 Timeslot information mapping

4.6.1.2.1 1.28 Mcps TDD

For 1.28 Mcps, the timeslots to be used for HS-PDSCH resources are signalled by the bits $x_{ts,1}$, $x_{ts,2}$, ..., $x_{ts,5}$, where bit $x_{ts,n}$ carries the information for timeslot n+1. Timeslots 0 and 1 cannot be used for HS-DSCH resources. If the signalling bit is set (i.e. equal to 1), then the corresponding timeslot shall be used for HS-PDSCH resources. Otherwise, the timeslot shall not be used. All used timeslots shall use the same channelisation code set, as signalled by the channelisation code set information bits.

4.6.1.2.2 3.84 Mcps TDD

For 3.84 Mcps, the timeslots to be used for HS-PDSCH resources are signalled by the bits $x_{ts,1}$, $x_{ts,2}$, ..., $x_{ts,13}$, where bit $x_{ts,n}$ carries the information for the nth available timeslot for HS-PDSCH resources, where the order of the timeslots available for HS-PDSCH resources shall be the same as the order of the 15 time slots within each frame with the following two slots removed:

- The slot containing the P-CCPCH
- The first slot in a frame containing the PRACH

If the P-CCPCH and/or PRACH are assigned to some, but not all frames, then the corresponding time slots shall remain unavailable for these frames as well..

If the bit is set (i.e. equal to 1), then the corresponding timeslot shall be used for HS-PDSCH resources. Otherwise, the timeslot shall not be used. All used timeslots shall use the same channelisation code set, as signalled by the channelisation code set information bits.

4.6.1.3 Modulation scheme information mapping

The modulation scheme to be used by the HS-PDSCH resources shall be signalled by bit $x_{ms,1}$. The mapping scheme in Table 17 shall apply.

Table 17: Modulation scheme information mapping

$x_{ms,1}$	Modulation Scheme
0	QPSK
1	16-QAM

4.6.1.4 Redundancy and constellation version information mapping

The redundancy version (RV) parameters r, s and constellation version parameter b are mapped jointly to produce the value X_{rv}. X_{rv} is alternatively represented as the sequence $x_{rv,1}$, $x_{rv,2}$, $x_{rv,3}$ where $x_{rv,1}$ is the MSB. This is done according to the following tables according to the modulation mode used:

Table 18: RV mapping for 16 QAM

X_{rv} (value)	s	r	b
0	1	0	0
1	0	0	0
2	1	1	1
3	0	1	1
4	1	0	1
5	1	0	2
6	1	0	3
7	1	1	0

Table 19: RV mapping for QPSK

X_{rv} (value)	s	r
0	1	0
1	0	0
2	1	1
3	0	1
4	1	2
5	0	2
6	1	3
7	0	3

4.6.1.5 HS-SCCH cyclic sequence number

The HS-SCCH cyclic sequence number is mapped such that $x_{hcsn,1}$ corresponds to the MSB and $x_{hcsn,3}$ to the LSB.

4.6.1.6 UE identity

The UE identity is the HS-DSCH Radio Network Identifier (H-RNTI) defined in [12]. This is mapped such that $x_{ue,1}$ corresponds to the MSB and $x_{ue,16}$ to the LSB, cf. [14].

4.6.1.7 HARQ process identifier mapping

The hybrid-ARQ process information $x_{hap,1}$, $x_{hap,2}$, $x_{hap,3}$ is unsigned binary representation of the HARQ process identifier where $x_{hap,1}$ is MSB.

4.6.1.8 Transport block size index mapping

The transport-block size information $x_{tbs,1}$, $x_{tbs,2}$, ..., $x_{tbs,m}$ is unsigned binary representation of the transport block size index where $x_{tbs,1}$ is MSB.

4.6.2 Multiplexing of HS-SCCH information

The information carried on the HS-SCCH is multiplexed onto the bits $a_1, a_2, \ldots a_A$ according to the following rule :

$$a_1, a_2 \ldots a_8 = x_{ccs,1}, x_{ccs,2} \ldots x_{ccs,8}$$

$$a_9, a_{10} \ldots a_{9+n-1} = x_{ts,1}, x_{ts,2} \ldots x_{ts,n}$$

$$a_{9+n} = x_{ms,1}$$

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$a_{9+n+1}, a_{9+n+2} \ldots a_{9+n+m} = x_{ibs,1}, x_{ibs,2} \ldots x_{ibs,m}$

$a_{10+n+m}, a_{11+n+m}, a_{12+n+m} = x_{hap,1}, x_{hap,2}, x_{hap,3}$

$a_{13+n+m}, a_{14+n+m}, a_{15+n+m} = x_{rv,1}, x_{rv,2}, x_{rv,3}$

$a_{16+n+m} = x_{nd,1}$

$a_{17+n+m}, a_{18+n+m}, a_{19+n+m} = x_{hcsn,1}, x_{hcsn,2}, x_{hcsn,3}$

4.6.3 CRC attachment for HS-SCCH

From the sequence of bits $a_1, a_2, \ldots a_A$ a 16 bit CRC is calculated according to Section 4.2.1.1. This gives a sequence of bits $y_1, y_2, \ldots y_{16}$ where

$y_k = p_{im(17-k)}$ k = 1,2,...16

This latter sequence of bits is then masked with the UE identity and appended to the sequence of bits $a_1, a_2, \ldots a_A$. The bits at the output of the CRC attachment block is the sequence of bits $b_1, b_2, \ldots b_B$, where

$b_i = a_i$ $i=1,2,\ldots,A$

$b_i = (y_{i-A} + x_{ue,i-A}) \bmod 2$ $i=A+1 \ldots B$

4.6.4 Channel coding for HS-SCCH

Channel coding for the HS-SCCH shall be done with the general method described in 4.2.3 with the following specific parameters:

The rate 1/3 convolutional coding shall be used for HS-SCCH.

4.6.5 Rate matching for HS-SCCH

Rate matching for HS-SCCH shall be done with the general method described in 4.2.7.

4.6.6 Interleaving for HS-SCCH

Interleaving for HS-SCCH shall be done with the general method described in 4.2.11.1.

4.6.7 Physical Channel Segmentation for HS-SCCH

Physical channel segmentation for HS-SCCH shall be done with the general method described in 4.2.10. For 1.28 Mcps TDD, the HS-SCCH consists of two physical channels HS-SCCH1 and HS-SCCH2; for 3.84 Mcps TDD the HS-SCCH only uses one physical channel, see [7].

4.6.8 Physical channel mapping for HS-SCCH

Physical channel mapping for the HS-SCCH shall be done with the general method described in subclause 4.2.12.

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4.7 Coding for HS-SICH

The following information, provided by higher layers, is transmitted by means of the HS-SICH physical channel.

- Recommended Modulation Format (RMF) (1 bit): $x_{rmf,1}$
- Recommended Transport-block size (RTBS) (n bits where n = 6 for 1.28 Mcps TDD and n = 9 for 3.84 Mcps TDD): $x_{tbs,1}, x_{tbs,2}, \ldots, x_{tbs,n}$
- Hybrid-ARQ information ACK/NACK (1 bit): $x_{an,1}$

The following coding/multiplexing steps can be identified:

- separate coding of RMF, RTBS and ACK/NACK (see subclause 4.7.2);
- multiplexing of HS-SICH information (4.7.3);
- interleaving for HS-SICH (see subclause 4.7.4);
- mapping to physical channels (see subclause 4.7.5).

The general coding/multiplexing flow is shown in the figure 20.

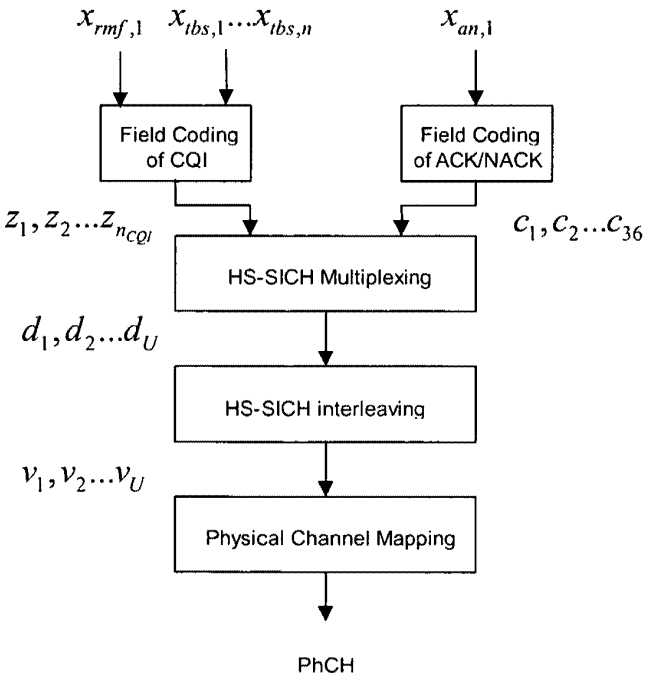


Figure 20Coding and multiplexing for HS-SICH

4.7.1 HS-SICH information field mapping

4.7.1.1 RMF information mapping

The RMF information bit, $x_{rmf,1}$, shall be mapped according to the mapping specified in subclause 4.6.1.3.

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4.7.1.2 RTBS information mapping

The RTBS information bits, $x_{tbs,1}$, $x_{tbs,2}$, ..., $x_{tbs,n}$, shall be mapped according to the same mapping as is used for the transport block size information bits in subclause 4.6. This mapping is defined by higher layers [12].

4.7.1.3 ACK/NACK information mapping

The ACK/NACK information bit $x_{an,1}$ shall be mapped according to the mapping given in Table 20 below.

Table 20: ACK/NACK information mapping

ACK/NACK	$x_{an,1}$
ACK	1
NACK	0

4.7.2 Coding for HS-SICH

4.7.2.1 Field Coding of ACK/NACK

The ACK/NACK bit $x_{an,1}$ shall be repetition coded to 36 bits. The coded bits are defined as $c_1 ... c_{36}$

4.7.2.2 Field Coding of CQI

4.7.2.2.1 Field Coding of CQI for 1.28 Mcps TDD

The quality information consists of Recommended Transport Block Size (RTBS) and Recommended Modulation Format (RMF) fields. The 6 bits of the RTBS field are coded to 32 bits using a (32, 6) 1st order Reed-Muller code. The coding procedure is as shown in figure 21.

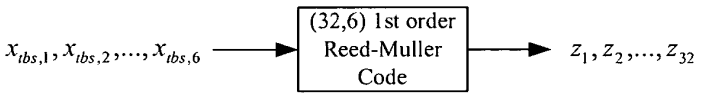


Figure 21: Field coding of RTBS information bits

The coding uses a subset basis sequences as the TFCI coder as described in subclause 4.3.1.1. The basis sequences that are used for RTBS coding are as follows in table 21.

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Table 21: Basis sequences for (32,6) RTBS code

i	$M_{i,0}$	$M_{i,1}$	$M_{i,2}$	$M_{i,3}$	$M_{i,4}$	$M_{i,5}$
0	1	0	0	0	0	1
1	0	1	0	0	0	1
2	1	1	0	0	0	1
3	0	0	1	0	0	1
4	1	0	1	0	0	1
5	0	1	1	0	0	1
6	1	1	1	0	0	1
7	0	0	0	1	0	1
8	1	0	0	1	0	1
9	0	1	0	1	0	1
10	1	1	0	1	0	1
11	0	0	1	1	0	1
12	1	0	1	1	0	1
13	0	1	1	1	0	1
14	1	1	1	1	0	1
15	1	0	0	0	1	1
16	0	1	0	0	1	1
17	1	1	0	0	1	1
18	0	0	1	0	1	1
19	1	0	1	0	1	1
20	0	1	1	0	1	1
21	1	1	1	0	1	1
22	0	0	0	1	1	1
23	1	0	0	1	1	1
24	0	1	0	1	1	1
25	1	1	0	1	1	1
26	0	0	1	1	1	1
27	1	0	1	1	1	1
28	0	1	1	1	1	1
29	1	1	1	1	1	1
30	0	0	0	0	0	1
31	0	0	0	0	1	1

The output RTBS code word bits $\{z_i : i = 1, \ldots, 32\}$ are given by:

$$z_i = \left(\sum_{n=1}^{6} x_{tbs,n} \cdot M_{i-1,n-1} \right) \bmod 2$$

The RMF bit $x_{rmf,1}$ is repetition coded to 16 bits to produce the bits . $z_{33}, z_{34}, \ldots, z_{n_{CQI}}$ where $n_{CQI} = 48$.

4.7.2.2.2 Field Coding of CQI for 3.84 Mcps TDD

RTBS and RMF bits are multiplexed onto the bits $y_1, y_2 \ldots y_{10}$ according to the following rule :

$$y_1 = x_{rmf,1}$$

$$y_2, y_3 \ldots y_{10} = x_{tbs,1}, x_{tbs,2} \ldots x_{tbs,9}$$

The bits $y_1, y_2 \ldots y_{10}$ are coded to produce the bits $w_1, w_2, \ldots w_{32}$ using a (32,10) sub-code of the second order Reed-Muller code as defined in subclause 4.3.1.1..

The bits $w_1, w_2, \ldots w_{32}$ are used to produce the CQI bits $z_1, z_2 \ldots z_{n_{CQI}}$ using a (4,1) repetition code, where $n_{CQI}=128$, such that:

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$z_n, z_{n+32}, z_{n+64}, z_{n+96} = w_n \qquad n=1...32$

4.7.3 Multiplexing of HS-SICH information fields

The CQI bits $z_1, z_2 ... z_{n_{CQI}}$ are multiplexed with the repetition coded ACK/NACK bits $c_1 ... c_{36}$ to produce the bits $d_1, d_2 ... d_U$ where U is the number of physical channel bits carried by HS-SICH, according to the following rule.:

$$d_1, d_2 ... d_{n_{CQI}} = z_{1,} z_2 ... z_{n_{CQI}}$$

$$d_{n_{CQI}+1}, d_{n_{CQI}+2} ... d_{n_{CQI}+36} = c_{1,} c_2 ... c_{36}$$

$$d_{n_{CQI}+37}, d_{n_{CQI}+38} ... d_U = 0,0....0$$

4.7.4 Interleaver for HS-SICH

Interleaver for HS-SICH shall be done with the general method described in 4.2.11.1.

4.7.5 Physical channel mapping for HS-SICH

Physical channel mapping for HS-SICH shall be done with the general method described in 4.2.12.

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Annex A (informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
14/01/00	RAN_05	RAN_05	-		Approved at TSG RAN #5 and placed under Change Control	-	3.0.0
14/01/00	RAN_06	RP-99694	001	3	Correction of rate matching parameters for repetition after 1st Interleaving in 25.222	3.0.0	3.1.0
14/01/00	RAN_06	RP-99694	002	1	Clarification of bit separation and collection	3.0.0	3.1.0
14/01/00	RAN_06	RP-99694	003	-	Changing the initial offset value for convolutional code rate matching	3.0.0	3.1.0
14/01/00	RAN_06	RP-99693	004	1	Editorial corrections to TS 25.222	3.0.0	3.1.0
14/01/00	RAN_06	RP-99694	007	-	Update of rate matching rule for TDD	3.0.0	3.1.0
14/01/00	RAN_06	RP-99694	009	1	Modified physical channel mapping scheme	3.0.0	3.1.0
14/01/00	RAN_06	RP-99694	013	-	Introduction of TFCI for S-CCPCH in TDD mode	3.0.0	3.1.0
14/01/00	RAN_06	RP-99694	015	-	TFCI coding and mapping in TDD	3.0.0	3.1.0
14/01/00	-	-	-		Change history was added by the editor	3.1.0	3.1.1
31/03/00	RAN_07	RP-000068	017	-	Corrections to TS 25.222	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	018	-	Refinements of Physical Channel Mapping	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	019	1	TFCI coding specification in TDD	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	021	-	Modification of Turbo code internal interleaver	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	023	-	Update of TS 25.222 - clarification of BTFD for TDD	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	025	-	Change of TFCI basis for TDD	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	026	-	Padding Function for Turbo coding of small blocks	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	027	-	Editorial modification of shifting parameter calculation for turbo code puncturing	3.1.1	3.2.0
31/03/00	RAN_07	RP-000068	029	1	Editorial changes of channel coding section	3.1.1	3.2.0
26/06/00	RAN_08	RP-000272	030	-	Parity bit attachment to 0 size transport block	3.2.0	3.3.0
26/06/00	RAN_08	RP-000272	031	-	Correction of the mapping formula	3.2.0	3.3.0
26/06/00	RAN_08	RP-000272	034	-	Alignment of Multiplexing for TDD	3.2.0	3.3.0
26/06/00	RAN_08	RP-000272	036	2	Bit separation of the Turbo encoded data	3.2.0	3.3.0
26/06/00	RAN_08	RP-000272	038	2	Revision of code block segmentation description	3.2.0	3.3.0
26/06/00	RAN_08	RP-000272	039	-	Editorial corrections in channel coding section	3.2.0	3.3.0
23/09/00	RAN_09	RP-000345	040	1	Update of TS 25.222	3.3.0	3.4.0
23/09/00	RAN_09	RP-000345	041	1	Editorial corrections in Turbo code internal interleaver section	3.3.0	3.4.0
23/09/00	RAN_09	RP-000345	042	-	Paging Indicator Terminology	3.3.0	3.4.0
23/09/00	RAN_09	RP-000345	043	1	Bit separation and collection for rate matching	3.3.0	3.4.0
23/09/00	RAN_09	RP-000345	048	-	Puncturing Limit definition in WG1 specification	3.3.0	3.4.0
15/12/00	RAN_10	RP-000543	049	-	Clarification on the Ci formula	3.4.0	3.5.0
15/12/00	RAN_10	RP-000543	050	-	Correction on TFCI & TPC Transmission	3.4.0	3.5.0
15/12/00	RAN_10	RP-000543	053	1	Editorial corrections in TS 25.222	3.4.0	3.5.0
16/03/01	RAN_11	-	-	-	Approved as Release 4 specification (v4.0.0) at TSG RAN #11	3.5.0	4.0.0
16/03/01	RAN_11	RP-010063	051	1	Bit Scrambling for TDD	3.5.0	4.0.0
16/03/01	RAN_11	RP-010063	054	1	Corrections & Clarifications for TS25.222	3.5.0	4.0.0
16/03/01	RAN_11	RP-010071	055	1	Inclusion of 1.28Mcps TDD in TS 25.222	3.5.0	4.0.0
21/09/01	RAN_13	RP-010523	057	-	TFCI Terminology	4.0.0	4.1.0
21/09/01	RAN_13	RP-010529	058	-	5ms TTI for PRACH for 1.28 Mcps TDD	4.0.0	4.1.0
21/09/01	RAN_13	RP-010529	060	-	A correction on the meaning of FPACH in TS 25.222	4.0.0	4.1.0
14/12/01	RAN_14	RP-010747	059	-	Bit Scrambling for TDD	4.1.0	4.2.0
14/12/01	RAN_14	RP-010747	061	-	Corrections in clause 4.1 and 4.2 of TS 25.222	4.1.0	4.2.0
08/03/02	RAN_15	RP-020050	063	1	Correction to addition of padding zeros to PICH in TDD	4.2.0	4.3.0
08/03/02	RAN_15	RP-020050	065	3	Clarification of the requirement for the determination of the rate matching parameters and editorial corrections to 25.222	4.2.0	4.3.0
08/03/02	RAN_15	RP-020058	066	2	Inclusion of HSDPA in 25.222	4.2.0	5.0.0
07/06/02	RAN_16	RP-020311	077	-	Second Stage Interleaving and Physical Channel Mapping	5.0.0	5.1.0
07/06/02	RAN_16	RP-020311	076	1	Zero padding for TFCI (3.84Mcps TDD)	5.0.0	5.1.0
07/06/02	RAN_16	RP-020314	073	-	Correction to addition of padding zeros to PICH in 1.28 Mcps TDD	5.0.0	5.1.0
07/06/02	RAN_16	RP-020314	086	-	Zero padding for TFCI (1.28Mcps TDD)	5.0.0	5.1.0
07/06/02	RAN_16	RP-020317	078	2	Removal of inconsistencies and ambiguities in the HARQ description	5.0.0	5.1.0
07/06/02	RAN_16	RP-020317	079	4	Corrections to HS-DSCH coding	5.0.0	5.1.0
07/06/02	RAN_16	RP-020317	082	1	Corrections to HSDPA Multiplexing and Coding	5.0.0	5.1.0
07/06/02	RAN_16	RP-020317	084	-	Introduction of HS-SCCH Cyclic Sequence Counter for TDD	5.0.0	5.1.0
19/09/02	RAN_17	RP-020570	097	1	Clarification of the definition of layer 1 transport channel numbers	5.1.0	5.2.0
19/09/02	RAN_17	RP-020585	093	-	HS-DSCH Interleaving for TDD	5.1.0	5.2.0
19/09/02	RAN_17	RP-020585	091	1	HS-SCCH corrections for TDD	5.1.0	5.2.0
19/09/02	RAN_17	RP-020585	089	1	Clarification of TFRI bits for 3.84Mcps HSDPA TDD	5.1.0	5.2.0
15/10/02	-	-	-	-	Moving of misplaced sections 4.6.1.5 and 4.6.1.6	5.2.0	5.2.1

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22/12/02	RAN_18	RP-020843	100	-	Corrections to TFCI encoding of very short TFCI lengths	5.2.1	5.3.0
22/12/02	RAN_18	RP-020843	102	-	Corrections to TFCI encoding of very short TFCI lengths	5.2.1	5.3.0
22/12/02	RAN_18	RP-020849	103	-	Correction of editorial Error	5.2.1	5.3.0
22/12/02	RAN_18	RP-020849	104	-	Miscellaneous Minor HSDPA Corrections	5.2.1	5.3.0
22/12/02	RAN_18	RP-020852	107	-	Editorial modification to the section numberings	5.2.1	5.3.0
25/03/03	RAN_19	RP-030139	108	1	HSDPA corrections	5.3.0	5.4.0
25/03/03	RAN_19	RP-030139	109	3	Miscellaneous Corrections	5.3.0	5.4.0
24/06/03	RAN_20	RP-030276	111	-	Corrections to field coding of CQI for HS-SICH (3.84Mcps TDD)	5.4.0	5.5.0
24/06/03	RAN_20	RP-030276	112	-	Correction to definition of number of bits available to HS-DSCH in one TTI.	5.4.0	5.5.0
06/01/04	RAN_22	RP-030646	118	1	Correction of subframe segmentation, physical channel mapping & rate matching for 1.28Mcps TDD	5.5.0	5.6.0
06/01/04	RAN_22	RP-030650	119	-	Clarification of the CRC attachment procedure for HS-SCCH (TDD)	5.5.0	5.6.0
06/01/04	RAN_22	RP-030660	120		HARQ process identifier mapping	5.5.0	5.6.0
06/01/04	RAN_22	RP-030712	121		Alignment of "Soft channel bits" terminology with 25.306	5.5.0	5.6.0
07/09/04	RAN_25	RP-040315	123	1	Correction of symbol Xi defined in sub-frame segmentation step	5.6.0	5.7.0

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3GPP TS 25.321 V3.13.0 (2002-09)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
MAC protocol specification
(Release 1999)



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Keywords
UMTS, radio

3GPP

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Foreword

This Technical Specification (TS) has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

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1 Scope

The present document specifies the MAC protocol.

The specification describes:

- MAC architecture;
- MAC entities;
- channel structure;
- services provided to upper layers;
- MAC functions;
- services expected from the physical layer;
- elements for layer-to-layer communication including primitives between MAC and RLC;
- elements for peer-to-peer communication;
- protocol data units, formats and parameters;
- elementary procedures.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document.*

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 25.301: "Radio Interface Protocol Architecture".

[3] 3GPP TS 25.302: "Services provided by the Physical Layer".

[4] 3GPP TS 25.303: "Interlayer Procedures in Connected Mode".

[5] 3GPP TS 25.304: "UE Procedures in Idle Mode and Procedures for Cell Reselection in Connected Mode".

[6] 3GPP TS 25.322: "RLC Protocol Specification".

[7] 3GPP TS 25.331: "Radio Resource Control (RRC); protocol specification".

[8] 3GPP TR 25.921: "Guidelines and Principles for Protocol Description and Error Handling".

[9] 3GPP TR 25.990: "Vocabulary for the UTRAN".

[10] 3GPP TS 33.102: "Security architecture".

[11] 3GPP TS 25.425: "UTRAN Iur Interface User Plane Protocols for Common Transport Channel Data Streams".

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[12] 3GPP TS 25.133: "Requirements for support of radio resource management (FDD)".

[13] 3GPP TS 25.214: "Physical layer procedures (FDD)".

[14] 3GPP TS 25.123: "Requirements for support of radio resource management (TDD)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in [9] and [1] apply.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ASC	Access Service Class
BCCH	Broadcast Control Channel
BCH	Broadcast Channel
C-	Control-
CCCH	Common Control Channel
CPCH	Common Packet Channel (UL)
DCCH	Dedicated Control Channel
DCH	Dedicated Channel
DL	Downlink
DSCH	Downlink Shared Channel
DTCH	Dedicated Traffic Channel
FACH	Forward Link Access Channel
FDD	Frequency Division Duplex
L1	Layer 1 (physical layer)
L2	Layer 2 (data link layer)
L3	Layer 3 (network layer)
MAC	Medium Access Control
PCCH	Paging Control Channel
PCH	Paging Channel
PDU	Protocol Data Unit
PHY	Physical layer
PhyCH	Physical Channels
RACH	Random Access Channel
RLC	Radio Link Control
RNC	Radio Network Controller
RNS	Radio Network Subsystem
RNTI	Radio Network Temporary Identity
RRC	Radio Resource Control
SAP	Service Access Point
SDU	Service Data Unit
SHCCH	Shared Channel Control Channel
SRNC	Serving Radio Network Controller
SRNS	Serving Radio Network Subsystem
TDD	Time Division Duplex
TFCI	Transport Format Combination Indicator
TFI	Transport Format Indicator
U-	User-
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System
USCH	Uplink Shared Channel
UTRA	UMTS Terrestrial Radio Access

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UTRAN UMTS Terrestrial Radio Access Network

4 General

4.1 Objective

The objective is to describe the MAC architecture and the different MAC entities from a functional point of view.

4.2 MAC architecture

The description in this subclause is a model and does not specify or restrict implementations.

According to the RRC functions the RRC is generally in control of the internal configuration of the MAC.

4.2.1 MAC Entities

The diagrams that describe the MAC architecture are constructed from MAC entities.

The entities are assigned the following names.

- MAC-b is the MAC entity that handles the following transport channels:
  - broadcast channel (BCH)
- MAC-c/sh, is the MAC entity that handles the following transport channels:
  - paging channel (PCH)
  - forward access channel (FACH)
  - random access channel (RACH)
  - common packet channel (UL CPCH). The CPCH exists only in FDD mode.
  - downlink shared channel (DSCH)
  - uplink shared channel (USCH). The USCH exists only in TDD mode.
- MAC-d is the MAC entity that handles the following transport channels:
  - dedicated transport channels (DCH)

The exact functions completed by the entities are different in the UE from those completed in the UTRAN.

NOTE: When a UE is allocated resources for exclusive use by the bearers that it supports the MAC-d entities dynamically share the resources between the bearers and are responsible for selecting the TFI/ TFCI that is to be used in each transmission time interval.

4.2.2 MAC-b

The following diagram illustrates the connectivity of the MAC-b entity in a UE and in each cell of the UTRAN.

MAC-b represents the control entity for the broadcast channel (BCH).

There is one (current cell) or multiple (current and neighbour cells) MAC-b entities in each UE and one MAC-b in the UTRAN for each cell.

The MAC Control SAP is used to transfer Control information to MAC-b.

The MAC-b entity is located in the Node B.

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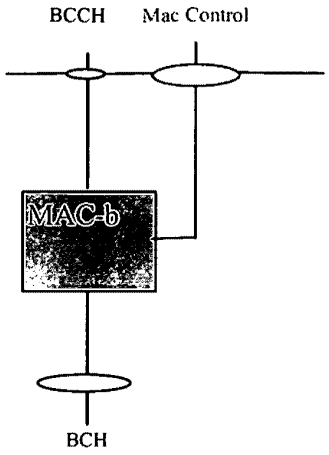


Figure 4.2.2.1: UE side and UTRAN side architecture

4.2.3 Traffic Related Architecture - UE Side

Figure 4.2.3.1 illustrates the connectivity of MAC entities.

The MAC-c/sh controls access to common transport channels.

The MAC-d controls access to dedicated transport channels.

If logical channels of dedicated type are mapped to common channels then MAC-d passes the data to MAC-c/sh via the illustrated connection between the functional entities.

The mapping of logical channels on transport channels depends on the multiplexing that is configured by RRC.

The MAC Control SAP is used to transfer Control information to each MAC entity.

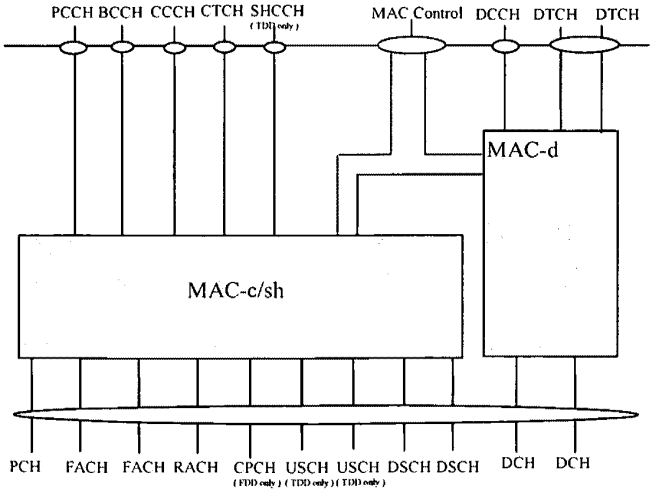


Figure 4.2.3.1: UE side MAC architecture

4.2.3.1 MAC-c/sh entity – UE Side

Figure 4.2.3.1.1 shows the UE side MAC-c/sh entity.

The following functionality is covered:

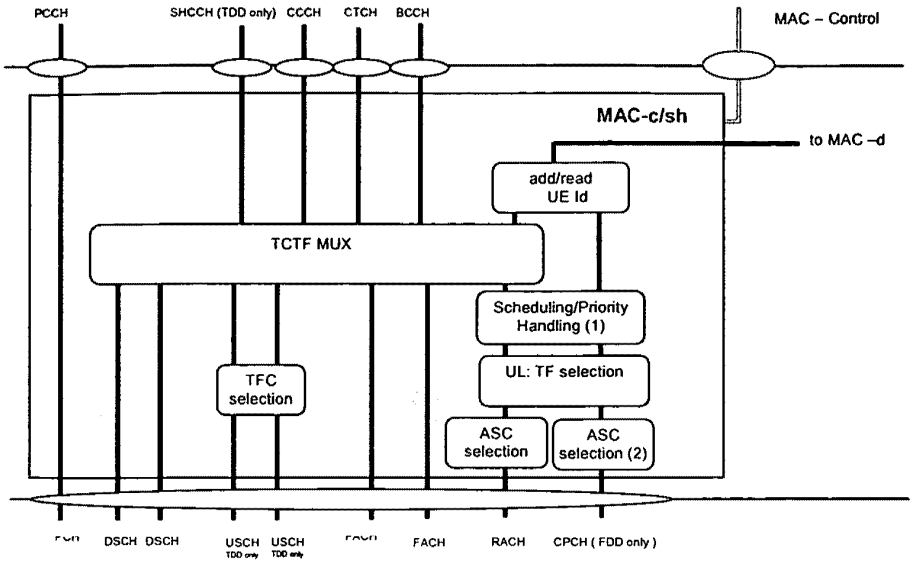
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- TCTF MUX:
  - this function represents the handling (insertion for uplink channels and detection and deletion for downlink channels) of the TCTF field in the MAC header, and the respective mapping between logical and transport channels.
    The TCTF field indicates the common logical channel type, or if a dedicated logical channel is used;
- add/read UE Id:
  - the UE Id is added for CPCH and RACH transmissions
  - the UE Id, when present, identifies data to this UE.
- UL: TF selection:
  - in the uplink, the possibility of transport format selection exists.
    In case of CPCH transmission, a TF is selected based on TF availability determined from status information on the CSICH;
- ASC selection:
  - For RACH, MAC indicates the ASC associated with the PDU to the physical layer. For CPCH, MAC may indicate the ASC associated with the PDU to the Physical Layer. This is to ensure that RACH and CPCH messages associated with a given Access Service Class (ASC) are sent on the appropriate signature(s) and time slot(s). MAC also applies the appropriate back-off parameter(s) associated with the given ASC. When sending an RRC CONNECTION REQUEST message, RRC will determine the ASC; in all other cases MAC selects the ASC;
- scheduling /priority handling
  - this functionality is used to transmit the information received from MAC-d on RACH and CPCH based on logical channel priorities. This function is related to TF selection.
- TFC selection
  - transport format and transport format combination selection according to the transport format combination set (or transport format combination subset) configured by RRC is performed,

The RLC provides RLC-PDUs to the MAC, which fit into the available transport blocks on the transport channels.

There is one MAC-c/sh entity in each UE.

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Note 1: Scheduling /Priority handling is applicable for CPCH.
Note 2: In case of CPCH, ASC selection may be applicable for AP preamble.

Figure 4.2.3.1.1: UE side MAC architecture / MAC-c/sh details

4.2.3.2 MAC-d entity – UE Side

Figure 4.2.3.2.1 shows the UE side MAC-d entity.

The following functionality is covered:

- Transport Channel type switching
  - Transport Channel type switching is performed by this entity, based on decision taken by RRC. This is related to a change of radio resources. If requested by RRC, MAC shall switch the mapping of one designated logical channel between common and dedicated transport channels.
- C/T MUX:
  - The C/T MUX is used when multiplexing of several dedicated logical channels onto one transport channel is used. An unambiguous identification of the logical channel is included.
- Ciphering:
  - Ciphering for transparent mode data to be ciphered is performed in MAC-d. Details about ciphering can be found in [10].
- Deciphering:
  - Deciphering for ciphered transparent mode data is performed in MAC-d. Details about ciphering can be found in [10].
- UL TFC selection:
  - Transport format and transport format combination selection according to the transport format combination set (or transport format combination subset) configured by RRC is performed.

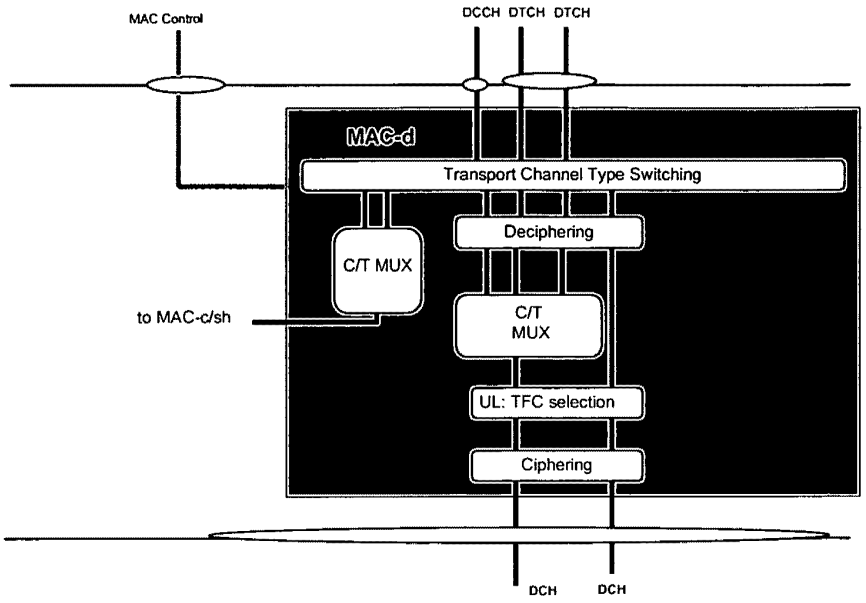
The MAC-d entity is responsible for mapping dedicated logical channels for the uplink either onto dedicated transport channels or to transfer data to MAC-c/sh to be transmitted via common channels.

One dedicated logical channel can be mapped simultaneously onto DCH and DSCH;

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The MAC-d entity has a connection to the MAC-c/sh entity. This connection is used to transfer data to the MAC-c/sh to transmit data on transport channels that are handled by MAC-c/sh (uplink) or to receive data from transport channels that are handled by MAC-c/sh (downlink).

There is one MAC-d entity in the UE.



Note 1: For DCH and DSCH different scheduling mechanism apply
Note 2: Ciphering is performed in MAC-d only for transparent RLC mode

Figure 4.2.3.2.1: UE side MAC architecture / MAC-d details

4.2.4 Traffic Related Architecture - UTRAN Side

Figure 4.2.4.1 illustrates the connectivity between the MAC entities from the UTRAN side.

It is similar to the UE case with the exception that there will be one MAC-d for each UE and each UE (MAC-d) that is associated with a particular cell may be associated with that cell's MAC-c/sh.

MAC-c/sh is located in the controlling RNC while MAC-d is located in the serving RNC.

The MAC Control SAP is used to transfer Control information to each MAC entity belongs to one UE.

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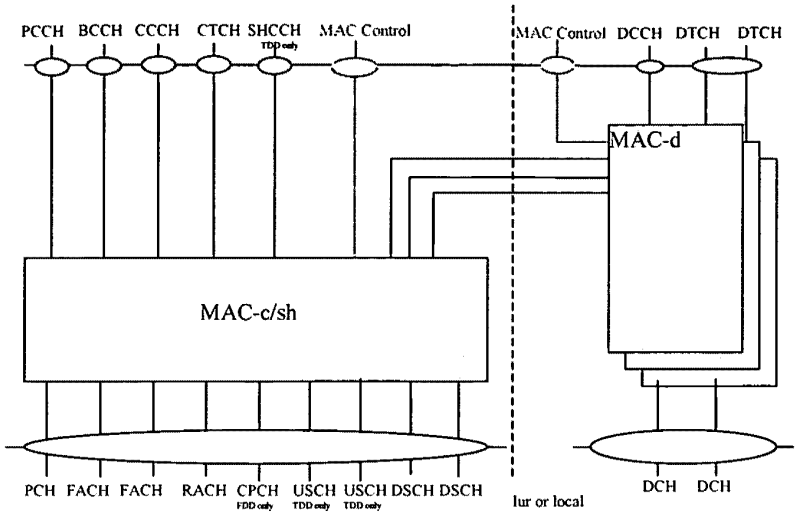


Figure 4.2.4.1: UTRAN side MAC architecture

4.2.4.1 MAC-c/sh entity – UTRAN Side

Figure 4.2.4.1.1 shows the UTRAN side MAC-c/sh entity. The following functionality is covered:

- the Scheduling – Priority Handling;
  - this function manages FACH and DSCH resources between the UEs and between data flows according to their priority.
- TCTF MUX
  - this function represents the handling (insertion for downlink channels and detection and deletion for uplink channels) of the TCTF field in the MAC header, and the respective mapping between logical and transport channels.
    The TCTF field indicates the common logical channel type, or if a dedicated logical channel is used;
- UE Id Mux;
  - for dedicated type logical channels, the UE Id field in the MAC header is used to distinguish between UEs;
- TFC selection:
  - in the downlink, transport format combination selection is done for FACH and PCH and DSCHs;
- demultiplex;
  - for TDD operation the demultiplex function is used to separate USCH data from different UEs, i.e. to be transferred to different MAC-d entities;
- DL code allocation;
  - this function is used to indicate the code used on the DSCH;

Flow control is provided to MAC-d.

The RLC provides RLC-PDUs to the MAC, which fit into the available transport blocks on the transport channels.

There is one MAC-c/sh entity in the UTRAN for each cell;

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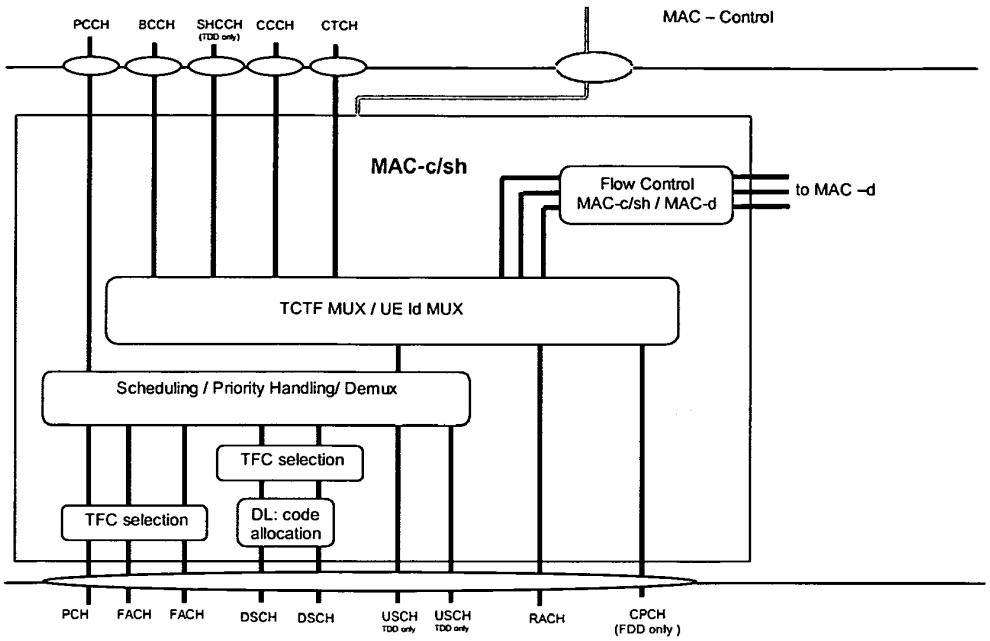


Figure 4.2.4.1.1: UTRAN side MAC architecture / MAC-c/sh details

4.2.4.2 MAC-d entity – UTRAN Side

Figure 4.2.4.2.1 shows the UTRAN side MAC-d entity.

The following functionality is covered:

- Transport Channel type switching:
  - Transport Channel type switching is performed by this entity, based on decision taken by RRC; this is related to a change of radio resources. If requested by RRC, MAC shall switch the mapping of one designated logical channel between common and dedicated transport channels.
- C/T MUX box;
  - the function includes the C/T field when multiplexing of several dedicated logical channels onto one transport channel is used.
- Priority setting;
  - This function is responsible for priority setting on data received from DCCH / DTCH;
- Ciphering;
  - Ciphering for transparent mode data to be ciphered is performed in MAC-d. Details about ciphering can be found in [10].
- Deciphering;
  - Deciphering for ciphered transparent mode data is performed in MAC-d. Details about ciphering can be found in [10].
- DL Scheduling/Priority handling;
  - in the downlink, scheduling and priority handling of transport channels is performed within the allowed transport format combinations of the TFCS assigned by the RRC.
- Flow Control;

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- a flow control function exists toward MAC-c/sh to limit buffering between MAC-d and MAC-c/sh entities. This function is intended to limit layer 2 signalling latency and reduce discarded and retransmitted data as a result of FACH or DSCH congestion. For the Iur interface this is specified in [11].

A MAC-d entity using common channels is connected to a MAC-c/sh entity that handles the scheduling of the common channels to which the UE is assigned and DL (FACH) priority identification to MAC-c/sh;

A MAC-d entity using downlink shared channel is connected to a MAC-c/sh entity that handles the shared channels to which the UE is assigned and indicates the level of priority of each PDU to MAC-c/sh;

A MAC-d entity is responsible for mapping dedicated logical channels onto the available dedicated transport channels or routing the data received on a DCCH or DTCH to MAC-c/sh.

One dedicated logical channel can be mapped simultaneously on DCH and DSCH. Different scheduling mechanisms apply for DCH and DSCH.

There is one MAC-d entity in the UTRAN for each UE that has one or more dedicated logical channels to or from the UTRAN.

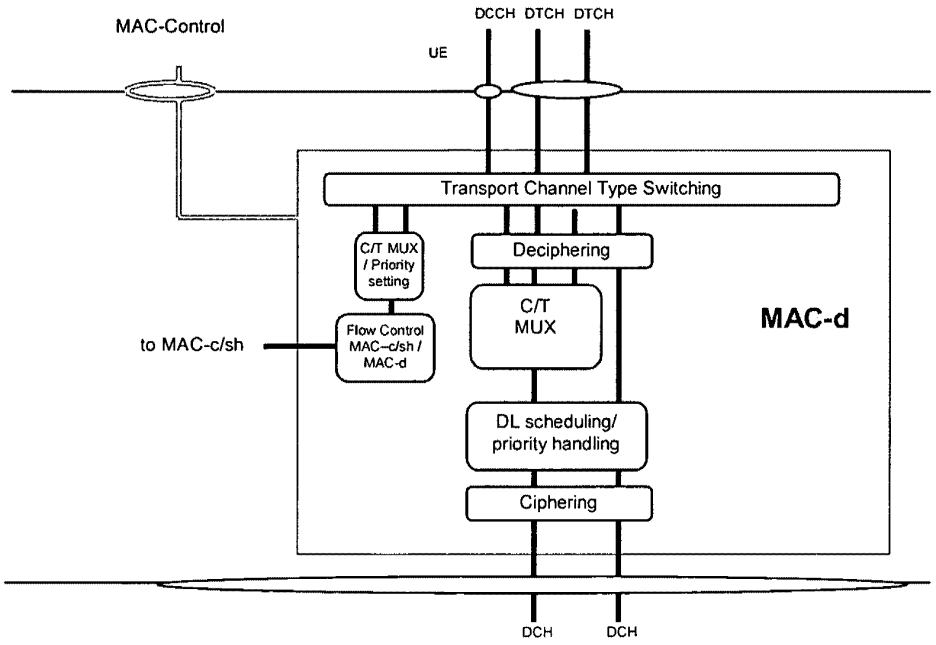


Figure 4.2.4.2.1: UTRAN side MAC architecture / MAC-d details

4.3 Channel structure

The MAC operates on the channels defined below; the transport channels are described between MAC and Layer 1, the logical channels are described between MAC and RLC.

The following subclauses provide an overview, the normative description can be found in [2] and [3] respectively.

4.3.1 Transport channels

Common transport channel types are:

- Random Access Channel(s) (RACH);
- Forward Access Channel(s) (FACH);

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- Downlink Shared Channel(s) (DSCH);
- Common Packet Channel(s) (CPCH) for UL FDD operation only;
- Uplink Shared Channel(s) (USCH), for TDD operation only;
- Broadcast Channel (BCH);
- Paging Channel (PCH).

Dedicated transport channel types are:

- Dedicated Channel (DCH).

4.3.2 Logical Channels

The MAC layer provides data transfer services on logical channels. A set of logical channel types is defined for different kinds of data transfer services as offered by MAC.

Each logical channel type is defined by what type of information is transferred.

4.3.2.1 Logical channel structure

The configuration of logical channel types is depicted in figure 4.3.2.1.

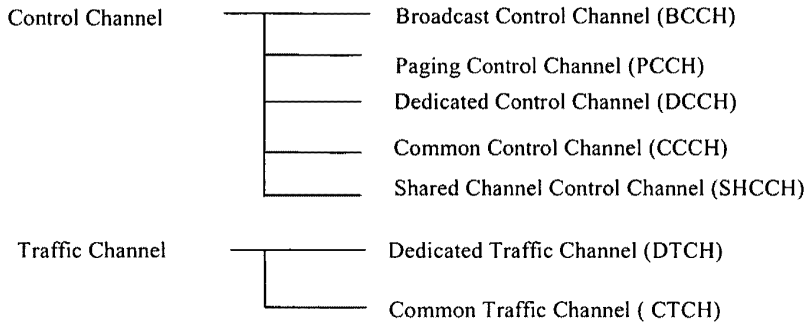


Figure 4.3.2.1: Logical channel structure

4.3.2.2 Control Channels

Following control channels are used for transfer of control plane information only:

- Broadcast Control Channel (BCCH);
- Paging Control Channel (PCCH);
- Common Control Channel (CCCH);
- Dedicated Control Channel (DCCH);
- Shared Channel Control Channel (SHCCH).

4.3.2.3 Traffic Channels

Following traffic channels are used for the transfer of user plane information only:

- Dedicated Traffic Channel (DTCH);
- Common Traffic Channel (CTCH).

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5 Services provided to upper layers

This clause describes the different services provided by the MAC to higher layers. For a detailed description of the following functions see [2].

5.1 Description of Services provided to upper layers

- Data transfer: This service provides unacknowledged transfer of MAC SDUs between peer MAC entities without data segmentation.
- Reallocation of radio resources and MAC parameters: This service performs on request of RRC execution of radio resource reallocation and change of MAC parameters.
- Reporting of measurements: Local measurements are reported to RRC.

6 Functions

6.1 Description of the MAC functions

The functions of MAC include:

- mapping between logical channels and transport channels;
- selection of appropriate Transport Format for each Transport Channel depending on instantaneous source rate;
- priority handling between data flows of one UE;
- priority handling between UEs by means of dynamic scheduling;
- identification of UEs on common transport channels;
- multiplexing/demultiplexing of upper layer PDUs into/from transport blocks delivered to/from the physical layer on common transport channels;
- multiplexing/demultiplexing of upper layer PDUs into/from transport block sets delivered to/from the physical layer on dedicated transport channels;
- traffic volume measurement;
- Transport Channel type switching;
- ciphering for transparent mode RLC;
- Access Service Class selection for RACH and CPCH transmission.

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6.2 Relation between MAC Functions and Transport Channels

6.2.1 Relation between MAC Functions and Transport Channels in UTRAN

Table 6.2.1.1: UTRAN MAC functions corresponding to the transport channel

Associated MAC Functions	Logical Ch	Transport Ch	TF Selection	Priority handling between UEs	Priority handling (one UE)	Scheduling	Identification of UEs	Mux/ Demux on common transport channels	Mux/ Demux on dedicated transport channels
Uplink (Rx)	CCCH	RACH						X	
	DCCH	RACH					X	X	
	DCCH	CPCH					X	X	
	DCCH	DCH							X
	DTCH	RACH					X	X	
	DTCH	CPCH					X	X	
	DTCH	DCH							X
	SHCCH	RACH					X	X	
	SHCCH	USCH						X	
	DTCH	USCH						X	
	DCCH	USCH						X	
Downlink (Tx)	BCCH	BCH				X			
	BCCH	FACH	X			X		X	
	PCCH	PCH	X			X			
	CCCH	FACH	X	X		X		X	
	CTCH	FACH	X			X		X	
	DCCH	FACH	X	X		X	X	X	
	DCCH	DSCH	X	X			X	X	
	DCCH	DCH	X		X				X
	DTCH	FACH	X	X		X	X	X	
	DTCH	DSCH	X	X			X	X	
	DTCH	DCH	X		X				X
	SHCCH	FACH	X	X		X		X	
	SHCCH	DSCH	X	X				X	

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6.2.2 Relation of MAC Functions and Transport Channels in UE

Table 6.2.2.1: UE MAC functions corresponding to the transport channel

Associated MAC Functions	Logical Ch	Transport Ch	TF Selection	Priority handling (one UE)	Identification	Mux/Demux on common transport channels	Mux/Demux on dedicated transport channels
Uplink (Tx)	CCCH	RACH				X	
	DCCH	RACH	X	X	X	X	
	DCCH	CPCH	X	X	X	X	
	DCCH	DCH	X	X			X
	DTCH	RACH	X	X	X	X	
	DTCH	CPCH	X	X	X	X	
	DTCH	DCH	X	X			X
	SHCCH	RACH				X	
	SHCCH	USCH	X	X		X	
	DCCH	USCH	X	X		X	
	DTCH	USCH	X	X		X	
Downlink (Rx)	BCCH	BCH					
	BCCH	FACH				X	
	PCCH	PCH					
	CCCH	FACH				X	
	CTCH	FACH				X	
	DCCH	FACH			X	X	
	DCCH	DSCH				X	
	DCCH	DCH					X
	DTCH	FACH			X	X	
	DTCH	DSCH				X	
	DTCH	DCH					X
	SHCCH	FACH				X	
	SHCCH	DSCH				X	

7 Services expected from physical layer

The physical layer offers information transfer services to MAC. For detailed description, see [3].

8 Elements for layer-to-layer communication

The interaction between the MAC layer and other layers are described in terms of primitives where the primitives represent the logical exchange of information and control between the MAC layer and other layers. The primitives shall not specify or constrain implementations. The MAC is connected to layer 1, RLC and RRC. The following subclauses describe the primitives between these layers.

8.1 Primitives between layers 1 and 2

The primitives are described in [3].

8.2 Primitives between MAC and RLC

8.2.1 Primitives

The primitives between MAC layer and RLC layer are shown in table 8.2.1.1.

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Table 8.2.1.1: Primitives between MAC layer and RLC layer

Generic Name	Parameter			
	Request	Indication	Response	Confirm
MAC-DATA	Data, BO, UE-ID type indicator, RLC Entity Info	Data, No_TB, TD (note), Error indication		
MAC-STATUS		No_PDU, PDU_Size, TX status	BO, RLC Entity Info	
NOTE: TDD only.				

MAC-DATA-Req/Ind:

- MAC-DATA-Req primitive is used to request that an upper layer PDU be sent using the procedures for the information transfer service;
- MAC-DATA-Ind primitive indicates the arrival of upper layer PDUs received within one transmission time interval by means of the information transfer service.

MAC-STATUS-Ind/Resp:

- MAC-STATUS-Ind primitive indicates to RLC for each logical channel the rate at which it may transfer data to MAC. Parameters are the number of PDUs that can be transferred in each transmission time interval and the PDU size; it is possible that MAC would use this primitive to indicate that it expects the current buffer occupancy of the addressed logical channel in order to provide for optimised TFC selection on transport channels with long transmission time interval. At the UE, MAC-STATUS-Ind primitive is also used to indicate from MAC to RLC that MAC has requested data transmission by PHY (i.e. PHY-DATA-REQ has been submitted, see Fig. 11.2.2.1), or that transmission of an RLC PDU on RACH or CPCH has failed due to exceeded preamble ramping cycle counter.
- MAC-STATUS-Resp primitive enables RLC to acknowledge a MAC-STATUS-Ind. It is possible that RLC would use this primitive to indicate that it has nothing to send or that it is in a suspended state or to indicate the current buffer occupancy to MAC.

8.2.2 Parameters

a) Data:

- it contains the RLC layer messages (RLC-PDU) to be transmitted, or the RLC layer messages that have been received by the MAC sub-layer.

b) Number of transmitted transport blocks (No_TB) :

- indicates the number of transport blocks transmitted by the peer entity within the transmission time interval, based on the TFI value.

c) Buffer Occupancy (BO):

- the parameter Buffer Occupancy (BO) indicates for each logical channel the amount of data in number of bytes that is available for transmission and retransmission in RLC layer. When MAC is connected to an AM RLC entity, control PDUs to be transmitted and RLC PDUs outside the RLC Tx window shall also be included in the BO. RLC PDUs that have been transmitted but not negatively acknowledged by the peer entity shall not be included in the BO.

d) RX Timing Deviation (TD), TDD only:

- it contains the RX Timing Deviation as measured by the physical layer for the physical resources carrying the data of the Message Unit. This parameter is optional and only for Indication. It is needed for the transfer of the RX Timing Deviation measurement of RACH transmissions carrying CCCH data to RRC.

e) Number of PDU (No_PDU):

- specifies the number of PDUs that the RLC is permitted to transfer to MAC within a transmission time interval.

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f) PDU Size (PDU_Size):

- specifies the size of PDU that can be transferred to MAC within a transmission time interval.

g) UE-ID Type Indicator:

- indicates the UE-ID type to be included in MAC for a DCCH and DTCH when they are mapped onto a common transport channel (i.e. FACH, RACH, DSCH in FDD or CPCH). On the UE side UE-ID Type Indicator shall always be set to C-RNTI.

h) TX status:

- when set to value "transmission unsuccessful" this parameter indicates to RLC that transmission of an RLC PDU failed in the previous Transmission Time Interval, when set to value "transmission successful" this parameter indicates to RLC that the requested RLC PDU(s) has been submitted for transmission by the physical layer.

i) RLC Entity Info

- indicates to MAC the configuration parameters that are critical to TFC selection depending on its mode and the amount of data that could be transmitted at the next TTI. This primitive is meant to insure that MAC can perform TFC selection (see subclause 11.4).

j) Error indication

- When a MAC SDU is delivered to upper layer, an error indication is given for the SDU to upper layer if an error indication for the SDU has been received from lower layer.

8.3 Primitives between MAC and RRC

8.3.1 Primitives

The primitives between MAC and RRC are shown in table 8.3.1.1.

Table 8.3.1.1: Primitives between MAC sub-layer and RRC

Generic Name	Parameter			
	Request	Indication	Response	Confirm
CMAC-CONFIG	UE information elements, RB information elements, TrCH information elements, RACH transmission control elements, Ciphering elements, CPCH transmission control elements			
CMAC-MEASUREMENT	Measurement information elements	Measurement result		
CMAC-STATUS		Status info		

CMAC-CONFIG-Req:

- CMAC-CONFIG-Req is used to request for setup, release and configuration of a logical channel, e.g. RNTI allocation, switching the connection between logical channels and transport channels, TFCS update or scheduling priority of logical channel.

CMAC-MEASUREMENT-Req/Ind:

- CMAC-MEASUREMENT-Req is used by RRC to request MAC to perform measurements, e.g. traffic volume measurements;

- CMAC-MEASUREMENT-Ind is used to notify RRC of the measurement result.

CMAC-STATUS-Ind:

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- CMAC-STATUS-Ind primitive notifies RRC of status information.

8.3.2 Parameters

See [7] for a detailed description of the UE, RB and TrCH information elements.

a) UE information elements
S-RNTI
SRNC identity
C-RNTI
Activation time

b) RB information elements
RB multiplexing info (Transport channel identity, Logical channel identity, MAC logical channel priority)

c) TrCH information elements
Transport Format Combination Set

d) Measurement information elements
Reporting Quantity identifiers
Time interval to take an average or a variance (applicable when Average or Variance is Reporting Quantity)

e) Measurement result
Reporting Quantity

f) Status info
when set to value ""transmission unsuccessful"" this parameter indicates to RRC that transmission of a TM RLC PDU failed (due to e.g. Maximum number of preamble ramping cycles reached for RACH in FDD), when set to value "transmission successful" this parameter indicates to RRC that the requested TM RLC PDU(s) has been submitted for transmission by the physical layer.

g) RACH transmission control elements
Set of ASC parameters (identifier for PRACH partitions, persistence values)
Maximum number of preamble ramping cycles M_{max}
Minimum and maximum number of time units between two preamble ramping cycles, N_{BO1min} and N_{BO1max}
ASC for RRC CONNECTION REQUEST message

h) Ciphering elements
Ciphering mode
Ciphering key
Ciphering sequence number

i) CPCH transmission control elements
CPCH persistency value, P for each Transport Format
Maximum number of preamble ramping cycles $N_{\_access\_fails}$
NF_max (Maximum number of frames for CPCH transmission for each Transport Format)
N_EOT (Number of EOT for release of CPCH transmission)
Backoff control timer parameters
Transport Format Set
Initial Priority Delays
Channel Assignment Active indication

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9 Elements for peer-to-peer communication

9.1 Protocol data units

9.1.1 General

A MAC PDU is a bit string, with a length not necessarily a multiple of 8 bits. In the drawings in clause 9.1, bit strings are represented by tables in which the first bit is the leftmost one on the first line of the table, the last bit is the rightmost on the last line of the table, and more generally the bit string is to be read from left to right and then in the reading order of the lines.

Depending on the provided service, MAC SDUs are bit strings with any non-null length, or bit strings with an integer number of octets in length. An SDU is included into a MAC PDU from first bit onward.

In the UE for the uplink, all MAC PDUs delivered to the physical layer within one TTI are defined as Transport Block Set (TBS). It consists of one or several Transport Blocks, each containing one MAC PDU. The Transport Blocks, shall be transmitted in the order as delivered from RLC. When multiplexing of RLC PDUs from different logical channels is performed on MAC, the order of all Transport Blocks originating from the same logical channel shall be the same as the order of the sequence delivered from RLC. The order of the different logical channels in a TBS is set by the MAC protocol.

9.1.2 MAC Data PDU

MAC PDU consists of an optional MAC header and a MAC Service Data Unit (MAC SDU), see figure 9.1.2.1. Both the MAC header and the MAC SDU are of variable size.

The content and the size of the MAC header depends on the type of the logical channel, and in some cases none of the parameters in the MAC header are needed.

The size of the MAC-SDU depends on the size of the RLC-PDU, which is defined during the setup procedure.

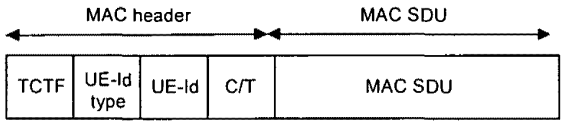


Figure 9.1.2.1: MAC data PDU

9.2 Formats and parameters

NOTE: MAC header field encodings as specified in this clause with designation "Reserved" are forbidden to be used by a sender in this version of the protocol.

9.2.1 MAC Data PDU: Parameters of the MAC header

The following fields are defined for the MAC header:

- Target Channel Type Field
  The TCTF field is a flag that provides identification of the logical channel class on FACH and RACH transport channels, i.e. whether it carries BCCH, CCCH, CTCH, SHCCH or dedicated logical channel information. The size and coding of TCTF for FDD and TDD are shown in tables 9.2.1.1, 9.2.1.2, 9.2.1.3, 9.2.1.4 and 9.2.1.5. Note that the size of the TCTF field of FACH for FDD is either 2 or 8 bits depending of the value of the 2 most significant bits and for TDD is either 3 or 5 bits depending on the value of the 3 most significant bits. The TCTF of the RACH for TDD is either 2 or 4 bits depending on the value of the 2 most significant bits.

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Table 9.2.1.1: Coding of the Target Channel Type Field on FACH for TDD

TCTF	Designation
000	BCCH
001	CCCH
010	CTCH
01100	DCCH or DTCH over FACH
01101-01111	Reserved (PDUs with this coding will be discarded by this version of the protocol)
100	SHCCH
101-111	Reserved (PDUs with this coding will be discarded by this version of the protocol)

Table 9.2.1.2: Coding of the Target Channel Type Field on FACH for FDD

TCTF	Designation
00	BCCH
01000000	CCCH
01000001-01111111	Reserved (PDUs with this coding will be discarded by this version of the protocol)
10000000	CTCH
10000001-10111111	Reserved (PDUs with this coding will be discarded by this version of the protocol)
11	DCCH or DTCH over FACH

Table 9.2.1.3: Coding of the Target Channel Type Field on USCH or DSCH (TDD only)

TCTF	Designation
0	SHCCH
1	DCCH or DTCH over USCH or DSCH

Table 9.2.1.4: Coding of the Target Channel Type Field on RACH for FDD

TCTF	Designation
00	CCCH
01	DCCH or DTCH over RACH
10-11	Reserved (PDUs with this coding will be discarded by this version of the protocol)

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Table 9.2.1.5: Coding of the Target Channel Type Field on RACH for TDD

TCTF	Designation
00	CCCH
0100	DCCH or DTCH Over RACH
0101-0111	Reserved (PDUs with this coding will be discarded by this version of the protocol)
10	SHCCH
11	Reserved (PDUs with this coding will be discarded by this version of the protocol)

- C/T field
  The C/T field provides identification of the logical channel instance when multiple logical channels are carried on the same transport channel. The C/T field is used also to provide identification of the logical channel type on dedicated transport channels and on FACH and RACH when used for user data transmission. The size of the C/T field is fixed to 4 bits for both common transport channels and dedicated transport channels. Table 9.2.1.5a shows the 4-bit C/T field.

Table 9.2.1.5a: Structure of the C/T field

C/T field	Designation
0000	Logical channel 1
0001	Logical channel 2
...	...
1110	Logical channel 15
1111	Reserved (PDUs with this coding will be discarded by this version of the protocol)

- UE-Id
  The UE-Id field provides an identifier of the UE on common transport channels. The following types of UE-Id used on MAC are defined:

  - UTRAN Radio Network Temporary Identity (U-RNTI) may be used in the MAC header of DCCH when mapped onto common transport channels in downlink direction; the U-RNTI is never used in uplink direction;

  - Cell Radio Network Temporary Identity (C-RNTI) is used on DTCH and DCCH in uplink, and may be used on DCCH in downlink and is used on DTCH in downlink when mapped onto common transport channels, except when mapped onto DSCH transport channel;

  - In FDD, DSCH Radio Network Temporary Identity (DSCH-RNTI) is used on DTCH and DCCH in downlink when mapped onto DSCH transport channel;- the UE id to be used by MAC is configured through the MAC control SAP. The lengths of the UE-id field of the MAC header are given in table 9.2.1.6.

Table 9.2.1.6: Lengths of UE Id field

UE Id type	Length of UE Id field
U-RNTI	32 bits
C-RNTI	16 bits
DSCH-RNTI	16 bits

- UE-Id Type
  The UE-Id Type field is needed to ensure correct decoding of the UE-Id field in MAC Headers.

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Table 9.2.1.7: UE-Id Type field definition

UE-Id Type field 2 bits	UE-Id Type
00	U-RNTI
01	C-RNTI or DSCH-RNTI
10	Reserved (PDUs with this coding will be discarded by this version of the protocol)
11	Reserved (PDUs with this coding will be discarded by this version of the protocol)

9.2.1.1 MAC header for DTCH and DCCH

a) DTCH or DCCH mapped to DCH, no multiplexing of dedicated channels on MAC:

- no MAC header is required.

b) DTCH or DCCH mapped to DCH, with multiplexing of dedicated channels on MAC:

- C/T field is included in MAC header.

c) DTCH or DCCH mapped to RACH/FACH:

- TCTF field, C/T field, UE-Id type field and UE-Id are included in the MAC header. For FACH, the UE-Id type field used is the C-RNTI or U-RNTI. For RACH, the UE-Id type field used is the C-RNTI.

d) DTCH or DCCH mapped to DSCH or USCH:

- the TCTF field is included in the MAC header for TDD only. The UE-Id type and UE-Id are included in the MAC header for FDD only. The UE-Id type field used is the DSCH-RNTI. The C/T field is included if multiplexing on MAC is applied.

e) DTCH or DCCH mapped to DSCH or USCH where DTCH or DCCH are the only logical channels:

- the UE-Id type and UE-Id are included in the MAC header for FDD only. The UE-Id type field used is the DSCH-RNTI. The C/T field is included in the MAC header if multiplexing on MAC is applied.

f) DTCH or DCCH mapped to CPCH:

- UE-Id type field and UE-Id are included in the MAC header. The C/T field is included in the MAC header if multiplexing on MAC is applied. The UE-Id type field used is the C-RNTI.

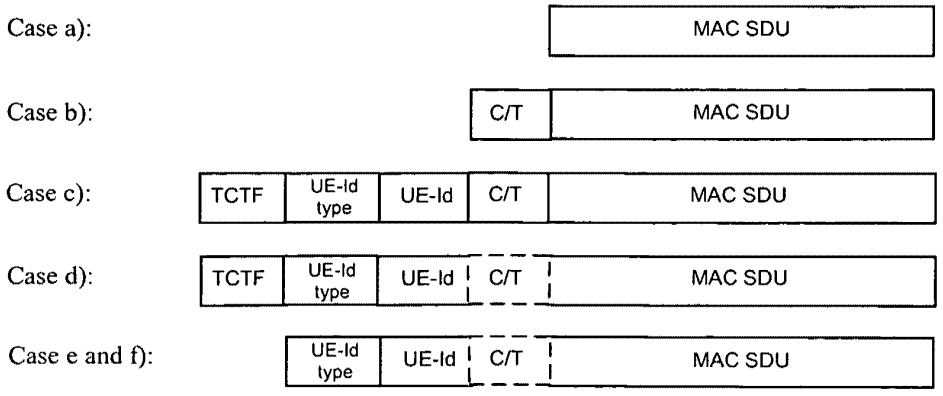


Figure 9.2.1.1.1: MAC Data PDU formats for DTCH and DCCH

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9.2.1.2 MAC header for BCCH

a) BCCH mapped to BCH:

- no MAC header is included.

b) BCCH mapped to FACH:

- the TCTF field is included in MAC header.

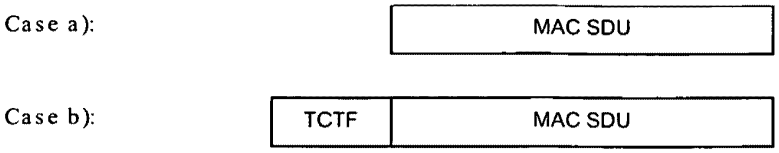


Figure 9.2.1.2.1: MAC Data PDU formats for BCCH

9.2.1.3 MAC header for PCCH

There is no MAC header for PCCH.

9.2.1.4 MAC header for CCCH

CCCH mapped to RACH/FACH:

- TCTF field is included in MAC header.

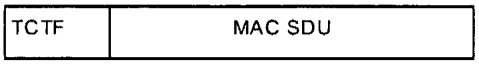


Figure 9.2.1.4.1: MAC Data PDU formats for CCCH

9.2.1.5 MAC Header for CTCH

The TCTF field is included as MAC header for CTCH as shown in figure 9.2.1.5.1.

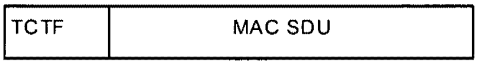


Figure 9.2.1.5.1: MAC Data PDU format for CTCH

9.2.1.6 MAC Header for SHCCH

The MAC header for SHCCH is as shown in figure 9.2.1.6.1.

a) SHCCH mapped to RACH and USCH/FACH and DSCH:

- TCTF has to be included.

b) SHCCH mapped to RACH and USCH/FACH and DSCH, where SHCCH is the only channel.

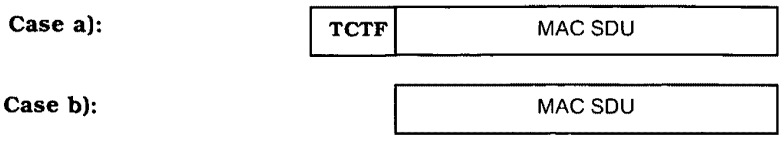


Figure 9.2.1.6.1: MAC Data PDU format for SHCCH

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10 Handling of unknown, unforeseen and erroneous protocol data

The list of error cases is reported below:

a) Use of reserved coding in the MAC header

If the MAC entity receives a Data PDU with a header field using a value marked as reserved for this version of the protocol, it shall discard the PDU, unless explicitly mentioned otherwise.

b) Inconsistent MAC header

If the MAC entity receives a data PDU with a header inconsistent with the configuration received from RRC, it shall discard the PDU. E.g.: In case DTCH is mapped to RACH/FACH, the MAC entity shall discard a PDU with a C/T field indicating a logical channel number that is not configured.

c) Erroneous MAC header fields

The MAC PDU shall be discarded if the lower layer gives an error indication for a MAC PDU and a MAC header is included in the MAC PDU.

11 Specific functions

11.1 Traffic volume measurement for dynamic radio bearer control

Dynamic radio bearer control is performed by RRC, based on the traffic volume measurements reported by MAC. Traffic volume information is measured in MAC layer and the results are reported from MAC layer to RRC layer.

At least every TTI, the MAC layer shall receive from each RLC entity the value of its Buffer Occupancy (BO), expressed in bytes. RRC can configure MAC to keep track of statistics (i.e. raw BO, average of BO and variance of BO) on the BO (see [7]) values of all Radio Bearers mapped onto a given transport channel. When the average or variance are requested, an averaging interval duration will also be provided.

Every time the BO values are reported to MAC, the UE shall verify whether an event was triggered or if a periodic report is required (see [7]). If reporting is required (multiple reports may be triggered in a single TTI), the MAC shall deliver to RRC the reporting quantities required for the corresponding RBs. In the case of average and variance of BO, the averaging should be performed for the interval with the configured duration ending at the time when the event was triggered.

RRC requests MAC measurement report with the primitive CMAC-Measure-REQ including following parameters.

Measurement information elements.

- Reporting Quantity identifiers
  Indicates what should be reported to RRC layer
  For each RB, BO (optional), Average of BO (optional), or Variance of BO(optional)

- Time interval to take an average or a variance (applicable when Average or Variance is Reporting Quantity)
  Indicates time interval to take an average or a variance of BO
  The calculation of average and variance of BO shall be based on one sample of BO per 10ms during the time interval given in this information element. All samples taken in the time interval shall have equal weight in the calculation.

MAC receives RLC PDUs with the primitive MAC-Data-REQ including following parameters.

- Buffer Occupancy (BO)
  The parameter Buffer Occupancy (BO) indicates for each logical channel the amount of data in number of bytes that is available for transmission and retransmission in RLC layer. When MAC is connected to an AM RLC

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entity, control PDUs to be transmitted and RLC PDUs outside the RLC Tx window shall also be included in the BO. RLC PDUs that have been transmitted but not negatively acknowledged by the peer entity shall not be included in the BO.

11.2 Control of RACH transmissions

The MAC sublayer is in charge of controlling the timing of RACH transmissions on transmission time interval level (the timing on access slot level is controlled by L1). Note that retransmissions in case of erroneously received RACH message part are under control of higher layers, i.e. RLC, or RRC for CCCH (and SHCCH for TDD).

11.2.1 Access Service Class selection

The physical RACH resources (i.e. access slots and preamble signatures for FDD, timeslot and channelisation code for TDD) may be divided between different Access Service Classes in order to provide different priorities of RACH usage. It is possible for more than one ASC or for all ASCs to be assigned to the same access slot/signature space.

Access Service Classes are numbered in the range $0 \leq i \leq \text{NumASC} \leq 7$ (i.e. the maximum number of ASCs is 8). An ASC is defined by an identifier i that defines a certain partition of the PRACH resources and an associated persistence value P_i. A set of ASC parameters consists of NumASC+1 such parameters (i, P_i), $i = 0, \ldots,$ NumASC. The PRACH partitions and the persistence values P_i are derived by the RRC protocol from system information (see [7]). The set of ASC parameters is provided to MAC with the CMAC-Config-REQ primitive. The ASC enumeration is such that it corresponds to the order of priority (ASC 0 = highest priority, ASC 7 = lowest priority). ASC 0 shall be used in case of Emergency Call or for reasons with equivalent priority.

At radio bearer setup/reconfiguration each involved logical channel is assigned a MAC Logical channel Priority (MLP) in the range 1,...,8. When the MAC sublayer is configured for RACH transmission in the UE, these MLP levels shall be employed for ASC selection on MAC.

The following ASC selection scheme shall be applied, where NumASC is the highest available ASC number and MinMLP the highest logical channel priority assigned to one logical channel:

- in case all TBs in the TB set have the same MLP, select ASC = min(NumASC, MLP);
- in case TBs in a TB set have different priority, determine the highest priority level MinMLP and select ASC = min(NumASC, MinMLP).

When an RRC CONNECTION REQUEST message is sent RRC determines ASC by means of the access class [7]. The ASC to be used in these circumstances is signalled to MAC by means of the CMAC-CONFIG-REQ message.

If MAC has knowledge of a U-RNTI then the ASC is determined in the MAC entity. If no U-RNTI has been indicated to MAC then MAC will use the ASC indicated in the CMAC-CONFIG-REQ primitive.

11.2.2 Control of RACH transmissions for FDD mode

The RACH transmissions are controlled by the UE MAC sublayer as outlined in figure 11.2.2.1.

NOTE: The figure shall illustrate the operation of the transmission control procedure as specified below. It shall not impose restrictions on implementation. MAC controls the timing of each initial preamble ramping cycle as well as successive preamble ramping cycles in case that none or a negative acknowledgement is received on AICH.

NOTE: In Cell-FACH state, the UE should co-ordinate the UL transmission schedule with the measurement schedule in FACH measurement occasions so as to minimise any delays associated with inter-frequency measurements.

MAC receives the following RACH transmission control parameters from RRC with the CMAC-CONFIG-Req primitive:

- a set of Access Service Class (ASC) parameters, which includes for each ASC, i=0,...,NumASC an identification of a PRACH partition and a persistence value P_i (transmission probability);
- maximum number of preamble ramping cycles M_{max};

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- range of backoff interval for timer T_{BOI}, given in terms of numbers of transmission 10 ms time intervals N_{BOImax} and N_{BOImin}, applicable when negative acknowledgement on AICH is received.

When there is data to be transmitted, MAC selects the ASC from the available set of ASCs, which consists of an identifier *i* of a certain PRACH partition and an associated persistence value P_i. The procedure to be applied for ASC selection is described in subclause 11.2.1.

Based on the persistence value P_i, the UE decides whether to start the L1 PRACH transmission procedure (see [13]) in the present transmission time interval or not. If transmission is allowed, the PRACH transmission procedure (starting with a preamble power ramping cycle) is initiated by sending of a PHY-ACCESS-REQ primitive. MAC then waits for access information from L1 via PHY-ACCESS-CNF primitive. If transmission is not allowed, a new persistency check is performed in the next transmission time interval. The persistency check is repeated until transmission is permitted.

When the preamble has been acknowledged on AICH, L1 access information with parameter value "ready for data transmission" is indicated to MAC with PHY-ACCESS-CNF primitive. Then data transmission is requested with PHY-DATA-REQ primitive, and the PRACH transmission procedure shall be completed with transmission of the PRACH message part according to L1 specifications. Successful completion (TX status) of the MAC transmission control procedure shall be indicated to higher layer.

When PHY indicates that no acknowledgement on AICH is received while the maximum number of preamble retransmissions is reached (defined by parameter Preamble_Retrans_Max on L1), a new persistency test is performed in the next transmission time interval. The timer T_2 ensures that two successive persistency tests are separated by at least one 10 ms time interval.

In case that a negative acknowledgement has been received on AICH a backoff timer T_{BOI} is started. After expiry of the timer, persistence check is performed again. Backoff timer T_{BOI} is set to an integer number N_{BOI} of 10 ms time intervals, randomly drawn within an interval $0 \leq N_{BOImin} \leq N_{BOI} \leq N_{BOImax}$ (with uniform distribution). N_{BOImin} and N_{BOImax} may be set equal when a fixed delay is desired, and even to zero when no delay other than the one due to persistency is desired.

Before a persistency test is performed it shall be checked whether any new RACH transmission control parameters have been received from RRC with CMAC-CONFIG-Req primitive. The latest set of RACH transmission control parameters shall be applied.

If the maximum number of preamble ramping cycles M_{max} is exceeded, failure of RACH transmission shall be reported to higher layer.

Both, transmission failure and successful completion of the MAC transmission control procedure, shall be indicated individually for each logical channel of which data was included in the transport block set of that access attempt. When transparent mode RLC is employed (i.e. for CCCH), transmission status is reported to RRC with CMAC-STATUS-Ind primitive. For logical channels employing acknowledged or unacknowledged mode RLC, transmission status is reported to RLC with MAC-STATUS-Ind primitive.

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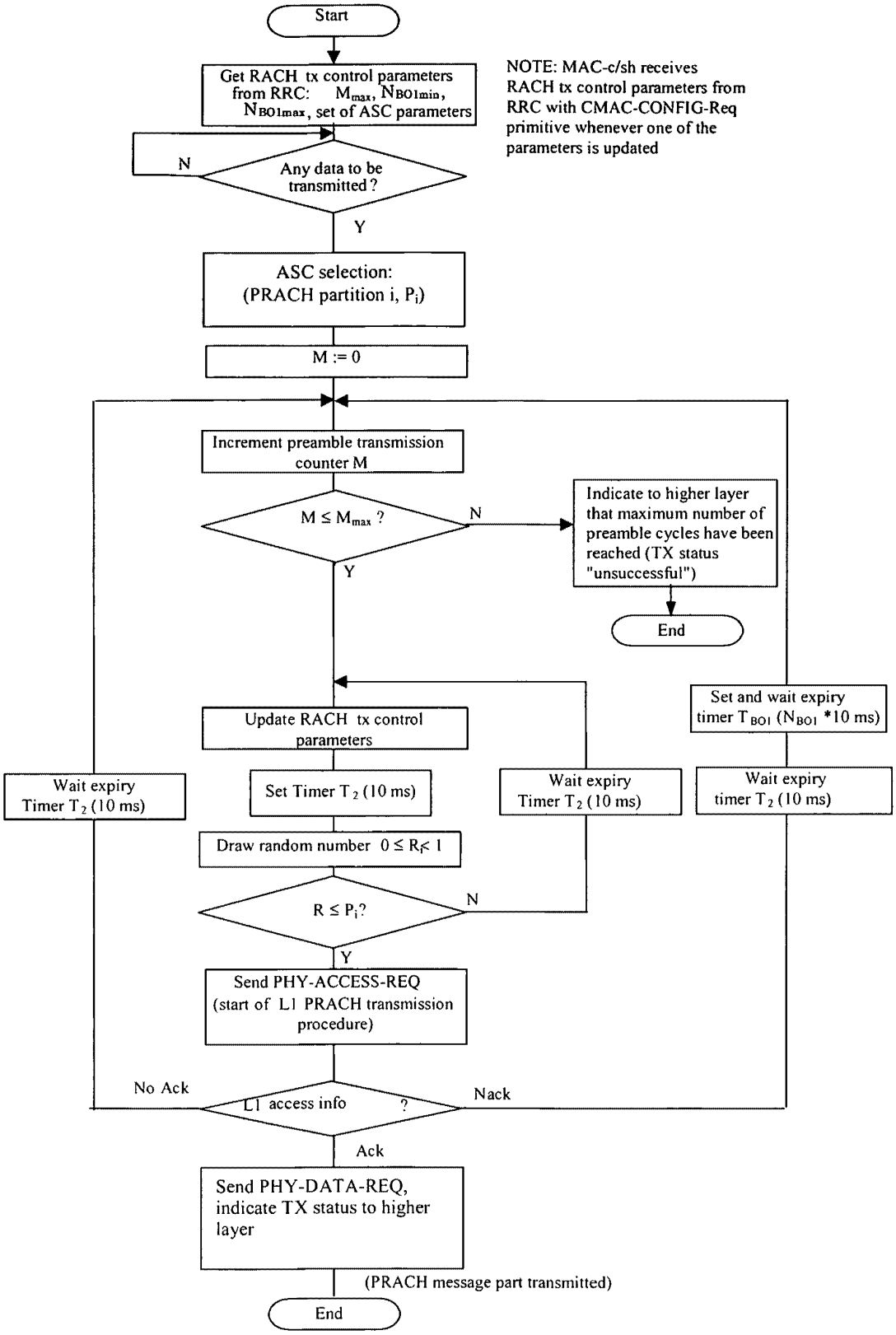


Figure 11.2.2.1: RACH transmission control procedure (UE side, informative)

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11.2.3 Control of RACH transmissions for TDD

The RACH transmissions are performed by the UE as shown in figure 11.2.3.2.

NOTE: The figure shall illustrate the operation of the transmission control procedure as specified below. It shall not impose restrictions on implementation.

MAC receives the following RACH transmission control parameters from RRC with the CMAC-Config-REQ primitive:

- a set of Access Service Class (ASC) parameters, which includes for each ASC, i=0,...,NumASC an identification of a PRACH partition and a persistence value P_i (transmission probability).

When there is data to be transmitted, MAC selects the ASC from the available set of ASCs, which consists of an identifier i of a certain PRACH partition and an associated persistence value P_i. The procedure to be applied for ASC selection is described in subclause 11.2.1.

In order to separate different ASCs each PRACH has N sub-channels associated with it (numbered from 0 to N-1). N may be assigned the value 1,2,4, or 8 by higher layer signalling. Sub-channel i for a PRACH defined in timeslot k is defined as the k:th slot in the frames where SFN mod N = i. Therefore follows the definition:

- Sub-channel i associated to a PRACH defined in timeslot k is defined as the k:th timeslot in the frames where SFN mod N = i.

Figure 11.2.3.1 illustrates the eight possible subchannels for the case, N=8. For illustration, the figure assumes that the PRACH is assigned timeslot 3.

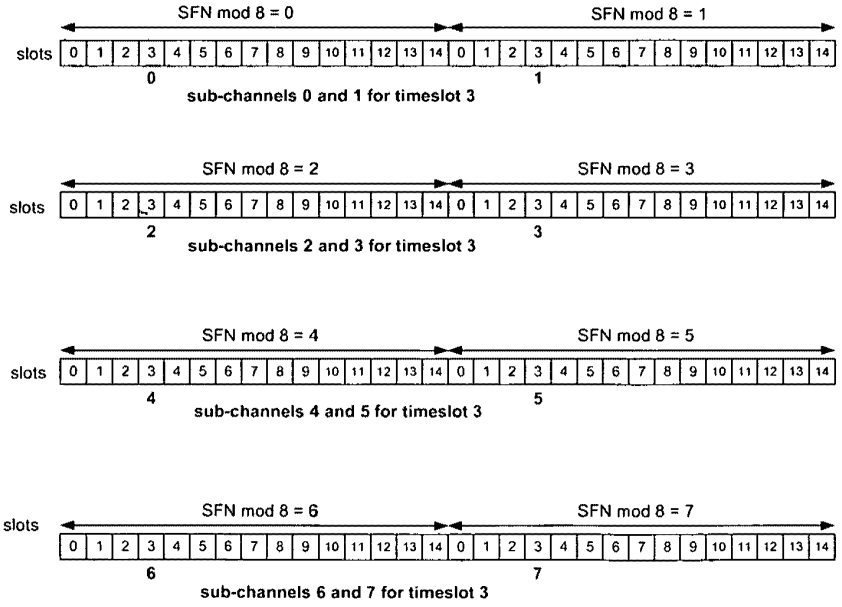


Figure 11.2.3.1 Eight sub-channels for timeslot 3

Based on the persistence value P, the UE decides whether to send the message on the RACH. If transmission is not allowed, a new persistency check is performed in the next transmission time interval. The persistency check is repeated until transmission is permitted. If transmission is allowed, a subchannel is randomly selected from the set of available subchannels for this ASC. The random subchannel selection shall be such that each of the allowed selections is chosen with equal probability. If an available subchannel is not found, the persistency check and subchannel assignment is repeated for the next subchannel period. If an available subchannel is found the PRACH transmission procedure is initiated by sending of a PHY-Data-REQ primitive.

Successful completion (TX status) of the MAC transmission control procedure shall be indicated to higher layer individually for each logical channel of which data was included in the transport block set of that access attempt. When transparent mode RLC is employed (i.e. for CCCH), transmission status is reported to RRC with CMAC-STATUS-Ind

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primitive. For logical channels employing acknowledged or unacknowledged mode RLC, transmission status is reported to RLC with MAC-STATUS-Ind primitive.

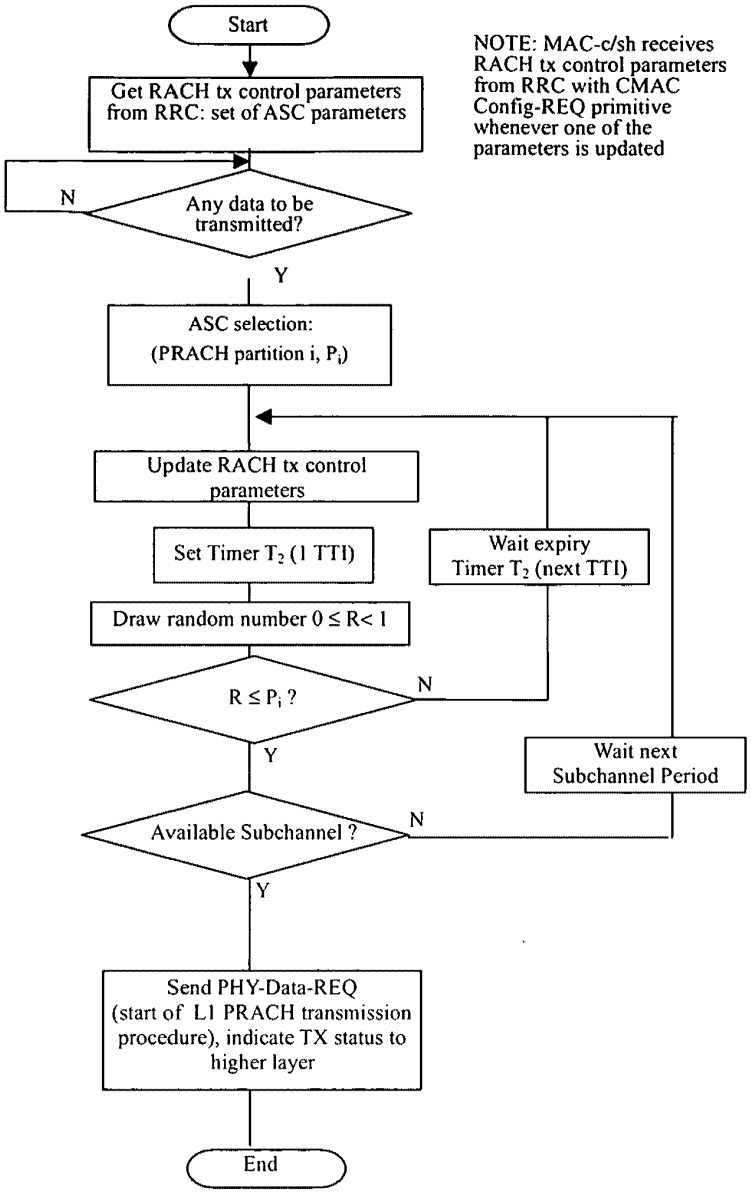


Figure 11.2.3.2: RACH transmission control procedure for TDD (UE side, informative)

11.3 Control of CPCH transmissions for FDD

The MAC layer controls the timing of CPCH transmissions on transmission time interval level (i.e. on 10, 20, 40 or 80 ms level); the timing on access slot level is controlled by L1. MAC controls the timing of each initial preamble ramping cycle as well as successive preamble ramping cycles. Note that retransmissions in case of erroneously received CPCH message part are under control of higher layers. The CPCH transmissions are performed by the UE as illustrated in figures 11.3.1 and 11.3.2. Figure 11.3.1 procedure is used for access to CPCH channel. Figure 11.3.2 procedure is used for CPCH Message transmission on the CPCH channel obtained using the access procedure.

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NOTE: In Cell-FACH state, the UE should co-ordinate the UL transmission schedule with the measurement schedule in FACH measurement occasions so as to minimise any delays associated with inter-frequency measurements.

MAC receives the following CPCH transmission control parameters from RRC with the CMAC-Config-REQ primitive:

- persistence values, P (transmission probability for each Transport Format (TF));
- N_access_fails, maximum number of preamble ramping cycles;
- NF_max, maximum number of frames for CPCH transmission for each TF;
- N_EOT (Number of EOT for release of CPCH transmission);
- Backoff control timer parameters;
- Transport Format Set;
- Initial Priority Delays;
- Channel Assignment Active indication.

The MAC procedure for CPCH access shall be invoked when the UE has data to transmit. The steps for this procedure are listed here:

1. the UE shall get all UL transmit parameters (CPCH Set Info, P values, Initial Priority Delays, N_access_fails, NF_max, N_EOT etc) from RRC;
2. the UE shall reset counter M, EOT counter and Frame Count Transmitted (FCT) upon entry to the initial access procedure;
3. if counter M is equal to N_access_fails, the UE shall indicate an access failure error to higher layer and the CPCH access procedure ends. Access failure is reported to RLC with MAC-STATUS-Ind primitive individually for each logical channel of which data was included in the transport block set that could not be transmitted. If counter M is less than N_access_fails, the UE shall send a PHY-CPCH_Status-REQ to Layer 1 to obtain CPCH TF subset status. If Layer 1 returns an error message, the UE shall increment counter M and the procedure shall continue from step 3. If Layer 1 returns a PHY-CPCH_Status-CNF message, which includes a TF subset indicating the currently available TFs of the requested TF subset, the procedure shall continue from step 4;
4. the UE shall initialise the Busy Table with the CPCH TF subset status from Layer 1. Those TFs in the TF subset of the Layer 1 PHY-CPCH_Status-CNF response will be marked available. All other TFs will be marked busy;
5. if all TFs are not marked busy, the procedure shall proceed from step 6. If all TFs are marked busy, the UE shall reset and start timer Tbocl, wait until timer expiry, and increment counter M. The procedure shall continue from step 3;
6. the UE shall update all UL transmit parameters from RRC;
7. UE shall select a TF from the set of available TFs listed in the Busy Table. UE shall use the CPCH channel capacity (transport block set size, NF_max, and TTI interval), and Busy Table information to select one CPCH TF for L1 to access. The UE may select a TF, which uses a lower data rate and a lower UL Tx power than the maximum UL Tx power allowed. UE shall implement a test based on the Persistence value (P) to determine whether to attempt access to the selected CPCH TF. If access is allowed, the procedure shall continue from step 9. If the P test does not allow access, the procedure shall continue from step 8;
8. the selected CPCH TF shall be marked busy in the Busy Table. If all TFs are marked busy, the UE shall reset and start timer Tbocl, wait until timer expiry, increment counter M, and continue from step 3. If all TFs are not marked busy, the UE shall resume the procedure from step 6;
9. the UE may implement an initial delay based on ASC of the data to be transmitted, then shall send a PHY-Access-REQ with the selected TF to L1 for CPCH access. After the UE has sent the access request to L1 , L1 shall return a PHY-Access-CNF including one of five access indications to MAC as shown in figure 11.3.1. If the L1 access indication is that access is granted, then UE shall continue from step 14. For the cases of the other Layer 1 responses, the procedure shall continue from step 10, 11, or 12 respectively.

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10. if L1 access indication is no AP-AICH received or no CD-AICH received, the UE shall reset and start timer Tboc3, wait until timer expiry, and increment counter M. The UE shall proceed from step 3;

11. if L1 access indication is AP-AICH_nak received, the UE shall reset and start timer Tboc2, wait until timer expiry. If Channel Assignment (CA) is active, the UE shall proceed from step 13. If Channel Assignment (CA) is not active, the procedure shall continue from step 8;

12. if L1 access indication is CD-AICH signature mismatch, the UE shall reset and start timer Tboc4, wait until timer expiry, and increment counter M. The procedure shall continue from step 3;

13. the UE shall increment counter M. The procedure shall continue from step 3.

14. the UE shall build a transport block set for the next TTI;

15. if the sum of the Frame Count Transmitted counter plus N_TTI (the number of frames in the next TTI) is greater than NF_max, the UE shall exit this procedure and start the MAC procedure for CPCH transmission of the first TTI. This shall release the CPCH channel in use and the UE will contend again for a new CPCH channel to continue transmission. If the sum of the Frame Count Transmitted counter plus N_TTI is less than or equal to NF_max, the UE shall send a PHY-Data-REQ with the transport block set to L1 to continue transmission on the CPCH channel which has previously been accessed;

16. if the L1 returns PHY-Status-IND indicating normal transmission, the procedure shall continue from step 17. If L1 returns PHY-Status-IND indicating abnormal situation the UE shall execute an abnormal situation handling procedure and the CPCH message transmission procedure ends. Reasons for abnormal situation may include the following:

    - emergency stop was received;
    - start of Message Indicator was not received;
    - L1 hardware failure has occurred;
    - out of synch has occurred;

17. the UE shall increment the Frame Count Transmitted (FCT) counter by N_TTI just transmitted and indicate TX Status "transmission successful" to RLC individually for each logical channel of which data was included in the transport block set. If the UE has more data to transmit, the procedure shall continue from step 14;

18. the UE shall build the next TTI with zero sized transport block set. If the sum of the Frame Count Transmitted counter plus N_TTI is less than or equal to NF_max and if the sum of the EOT counter plus N_TTI is less than or equal to N_EOT, the procedure shall continue from step 19. Otherwise, the procedure ends;

19. UE shall send a PHY-Data-REQ with zero sized transport block set to L1 to stop transmission on the CPCH channel which has previously been accessed, both the EOT and the FCT counters shall be incremented by N_TTI and the procedure shall continue from step 18.

Table 11.3: CPCH Backoff Delay Timer Values

Timer	Based on parameter	Fixed/random
T_{BOC1} (all Busy)	NF_bo_all_busy	Random
T_{BOC2} (channel Busy)	NS_bo_busy	Fixed
T_{BOC3} (no AICH)	NF_bo_no_aich	Fixed
T_{BOC4} (mismatch)	NF_bo_mismatch	Random

For T_{BOC4}, UE shall randomly select a timer value at each execution of the timer. A uniform random draw shall be made to select an integer number of frames within the range [0, NF_bo_mismatch]. For T_{BOC1}, UE would randomly select a timer value at each execution of the timer. A uniform random draw shall be made to select an integer number of frames within the range [0, NF_bo_all busy].

NOTE: Backoff parameter range and units are specified in [7], RRC Protocol Specification.

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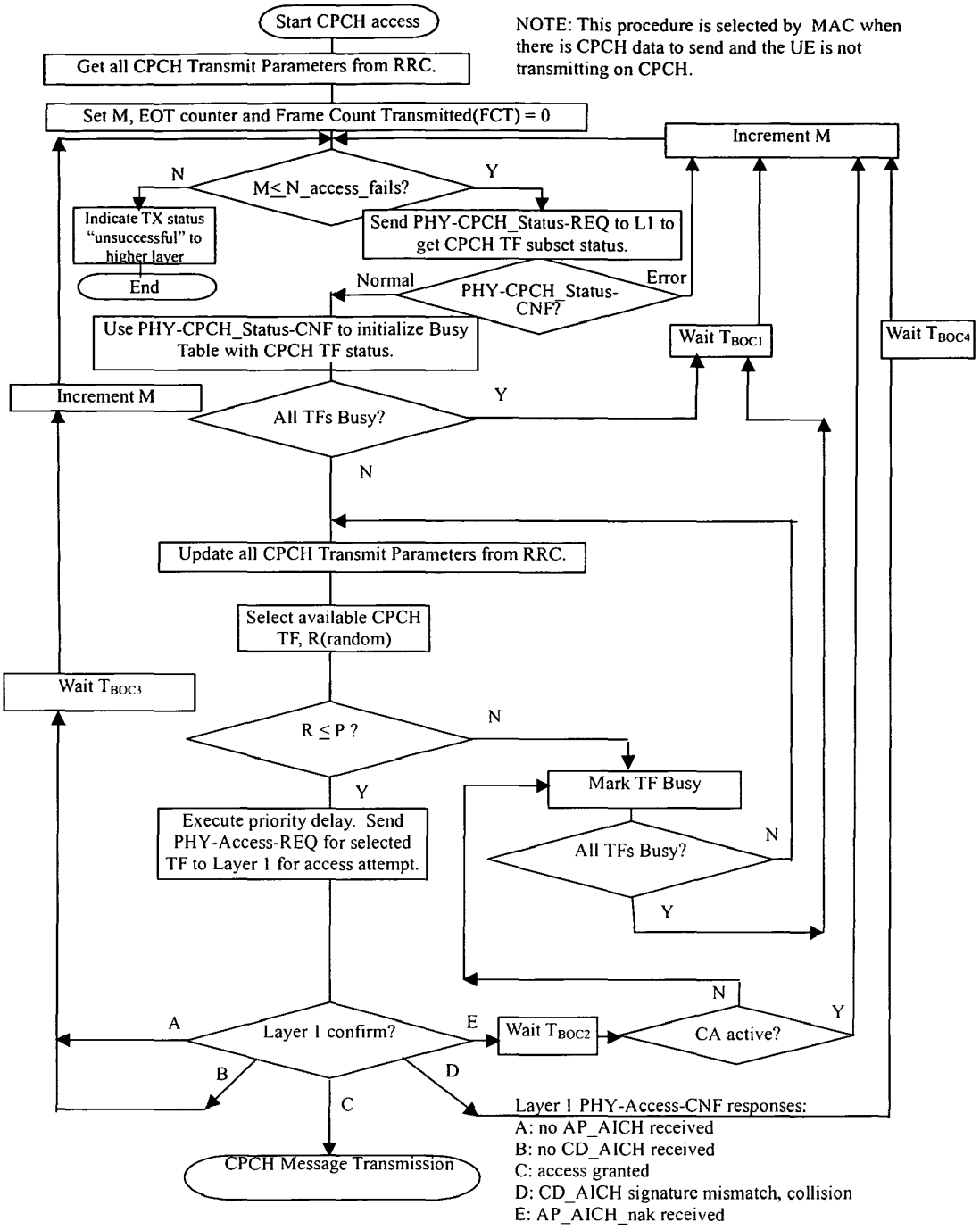


Figure 11.3.1: CPCH transmission control procedure for access (informative)

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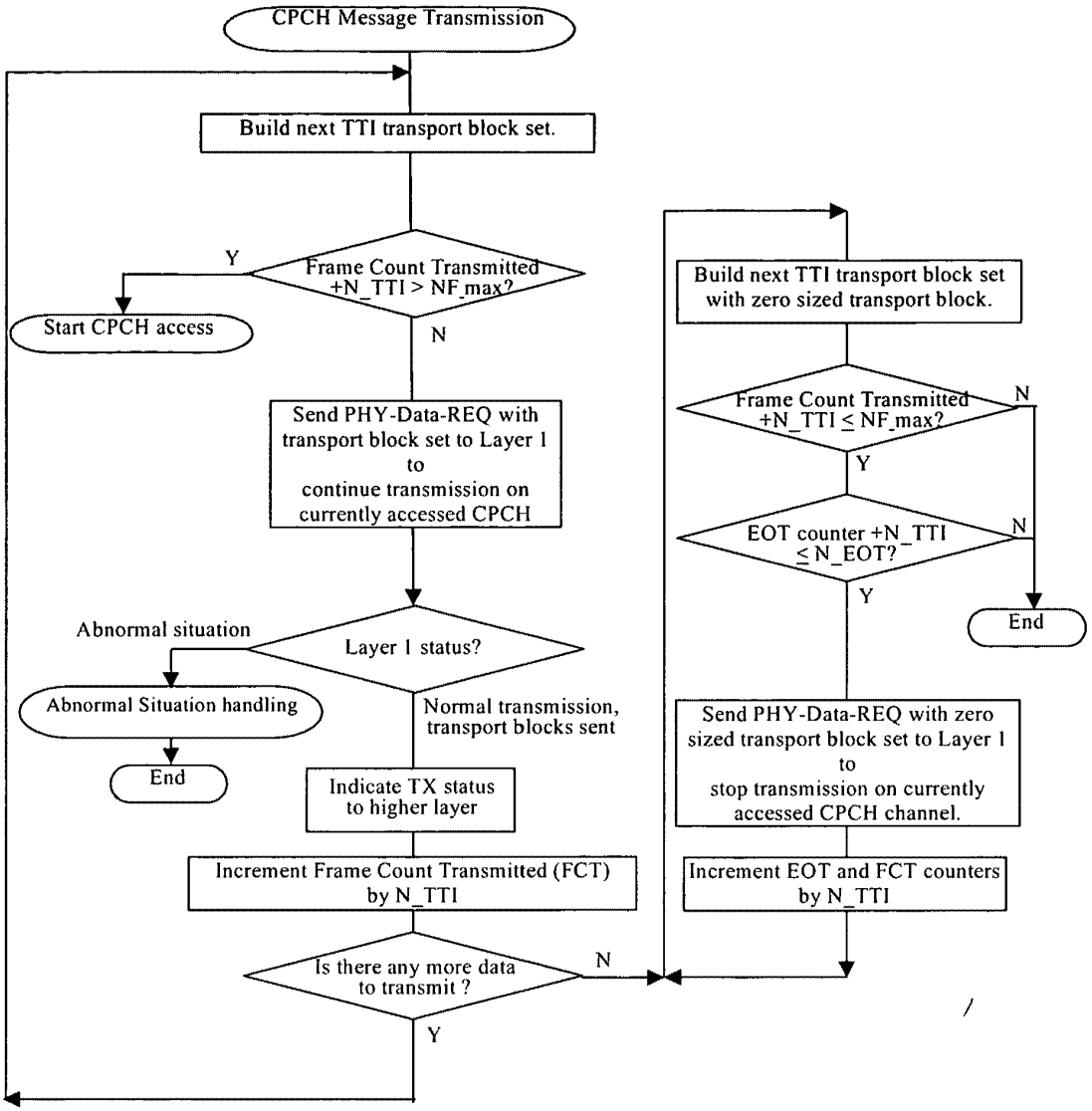


Figure 11.3.2: CPCH transmission control procedure for CPCH Message Transmission (informative)

11.4 Transport format combination selection in UE

RRC can control the scheduling of uplink data by giving each logical channel a priority between 1 and 8, where 1 is the highest priority and 8 the lowest. TFC selection in the UE shall be done in accordance with the priorities indicated by RRC. Logical channels have absolute priority, i.e. the UE shall maximise the transmission of higher priority data.

If the uplink TFCS configured by UTRAN follows the guidelines described in [7] the UE shall perform the TFC selection according to the rules specified below. If these guidelines are not followed then the UE behaviour is not specified.

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The UE shall continuously monitor the state for each TFC based on its required transmit power versus the maximum UE transmit power. A given TFC can be in any of the following states:

- Supported state;
- Excess-power state;
- Blocked state.

The following diagram illustrates the state transitions for the state of a given TFC:

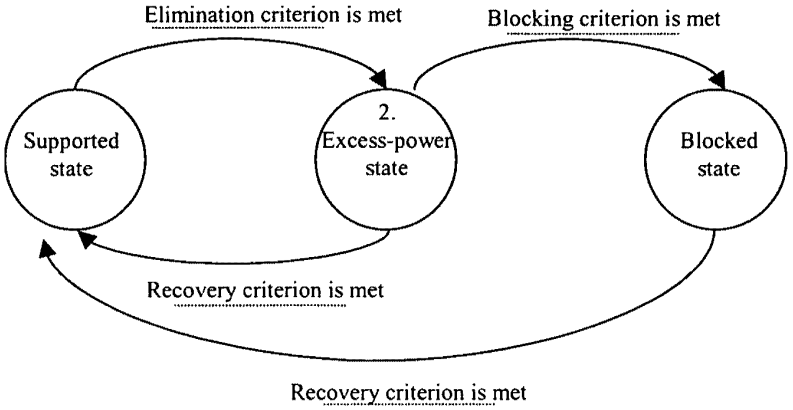


Figure 11.4.1: State transitions for the state of a given TFC

The state transition criteria and the associated requirements are described in [12, 14]. The UE shall consider that the Blocking criterion is never met for TFCs included in the minimum set of TFCs (see [7]).

Every time the set of supported TFCs changes, the available bitrate shall be indicated to upper layers for each logical channel in order to facilitate the adaptation of codec data rates when codecs supporting variable-rate operation are used. The details of the computation of the available bitrate and the interaction with the application layer are not further specified.

Before selecting a TFC, i.e. at every boundary of the shortest TTI, the set of valid TFCs shall be established. All TFCs in the set of valid TFCs shall:

1. belong to the TFCS.
2. not be in the Blocked state.
3. be compatible with the RLC configuration.
4. not require RLC to produce padding PDUs (see [6] for definition).
5. not carry more bits than can be transmitted in a TTI (e.g. when compressed mode by higher layer scheduling is used and the presence of compressed frames reduces the number of bits that can be transmitted in a TTI using the Minimum SF configured).

The UE may remove from the set of valid TFCs, TFCs in Excess-power state in order to maintain the quality of service for sensitive applications (e.g. speech). Additionally, if compressed frames are present within the longest configured TTI to which the next transmission belongs, the UE may remove TFCs from the set of valid TFCs in order to account for the higher power requirements.

The chosen TFC shall be selected from within the set of valid TFCs and shall satisfy the following criteria in the order in which they are listed below:

1. No other TFC shall allow the transmission of more highest priority data than the chosen TFC.
2. No other TFC shall allow the transmission of more data from the next lower priority logical channels. Apply this criterion recursively for the remaining priority levels.

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3. No other TFC shall have a lower bit rate than the chosen TFC.

The above rules for TFC selection in the UE shall apply to DCH, and the same rules shall apply for TF selection on RACH and CPCH.

11.5 Ciphering

The ciphering function is performed in MAC (i.e. only in MAC-d) if a radio bearer is using the transparent RLC mode. The data unit that is ciphered is the MAC SDU and this is shown in Figure 11.5.1 below.

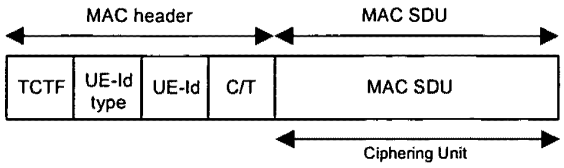


Figure 11.5.1: Ciphering unit for a MAC PDU

The ciphering algorithm and key to be used are configured by upper layers [7] and the ciphering method shall be applied as specified in [10].

The parameters that are required by MAC for ciphering are defined in [10] and are input to the ciphering algorithm. The parameters required by MAC which are provided by upper layers [7] are listed below:

- MAC-d HFN (Hyper frame number for radio bearers that are mapped onto transparent mode RLC)
- BEARER (Radio Bearer ID)
- CK (Ciphering Key)

If the TTI consists of more than one 10 ms radio frame, the CFN of the first radio frame in the TTI shall be used as input to the ciphering algorithm for all the data in the TTI.

If the activation time indicated by higher layers for start or stop of ciphering or change of ciphering parameters is not the first CFN in a TTI common to all the transport channels that are multiplexed onto the same CCTrCh, the activation time shall be applied at the first CFN in the following TTI common to all the transport channels that are multiplexed onto the same CCTrCh.

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Annex A (informative): Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
06/1999	RP-04	RP-99312	-		Approved at TSG-RAN #4 and placed under Change Control	-	3.0.0
10/1999	RP-05	RP-99463	001	1	Modified MAC handling of PCH and FACH	3.0.0	3.1.0
	RP-05	RP-99463	002		Modifications of MAC primitives	3.0.0	3.1.0
	RP-05	RP-99463	003	2	RACH/FACH MAC header – Channel type identification	3.0.0	3.1.0
	RP-05	RP-99463	004		Support for USCH/DSCH signalling in TDD	3.0.0	3.1.0
	RP-05	RP-99463	006		Clarification on RACH partitioning and prioritization via access service class (ASC) and relation to back-off algorithm	3.0.0	3.1.0
	RP-05	RP-99463	010	1	Modifications on UE-Id formats	3.0.0	3.1.0
	RP-05	RP-99463	011		CPCH primitives	3.0.0	3.1.0
	RP-05	RP-99463	012		Timing advance for TDD	3.0.0	3.1.0
	RP-05	RP-99463	013	1	Traffic volume measurement report procedure	3.0.0	3.1.0
	RP-05	RP-99463	014		Mapping of BCCH logical channel onto FACH transport channel	3.0.0	3.1.0
	RP-05	RP-99463	015	1	MAC PDU formats for DCCH/DTCH on DSCH and for PCCH	3.0.0	3.1.0
	RP-05	RP-99463	016	1	Informative parts that shall not specify or constrain implementations	3.0.0	3.1.0
	RP-05	RP-99463	017	1	Modification of RACH transmission control procedure	3.0.0	3.1.0
	RP-05	RP-99463	018		Removal of MAC function for system information and paging scheduling	3.0.0	3.1.0
	RP-05	RP-99463	019	1	RACH transmission control procedure on MAC for TDD mod	3.0.0	3.1.0
	RP-05	RP-99463	021	1	Removal of Annex A and B of TS 25.321	3.0.0	3.1.0
12/1999	RP-06	RP-99638	022	3	Modified MAC header field sizes	3.1.0	3.2.0
	RP-06	RP-99638	023		MAC: Multiple shared channels (DSCH/USCH)	3.1.0	3.2.0
	RP-06	RP-99638	024		Parameters for Status Primitive	3.1.0	3.2.0
	RP-06	RP-99638	025	1	Support of shared channel operation in TDD	3.1.0	3.2.0
	RP-06	RP-99638	028		Modification of Cell Broadcast Service (CBS)	3.1.0	3.2.0
	RP-06	RP-99637	030	1	Editorial changes	3.1.0	3.2.0
	RP-06	RP-99638	031	1	Simultaneous mapping of logical channels on	3.1.0	3.2.0
03/2000	RP-07	RP-000039	032		Bit Aligned TDD MAC Headers	3.2.0	3.3.0
	RP-07	RP-000039	035	2	CPCH including Channel Assignment	3.2.0	3.3.0
	RP-07	RP-000039	036		UE-ID type indication	3.2.0	3.3.0
	RP-07	RP-000039	037	1	RACH transmission control procedure	3.2.0	3.3.0
	RP-07	RP-000039	039		CPCH start of message indication	3.2.0	3.3.0
	RP-07	RP-000039	040		Removal of SCH and SCCH	3.2.0	3.3.0
	RP-07	RP-000039	041	1	Clarification of bit order	3.2.0	3.3.0
06/2000	RP-08	RP-000219	042		CPCH correction	3.3.0	3.4.0
	RP-08	RP-000219	043	1	End of CPCH transmission	3.3.0	3.4.0
	RP-08	RP-000219	044	2	Clarification of prioritisation of logical channels in UE	3.3.0	3.4.0
	RP-08	RP-000219	045	1	CPCH MAC procedures	3.3.0	3.4.0
	RP-08	RP-000219	046		Traffic Volume Measurement for dynamic radio bearer control	3.3.0	3.4.0
09/2000	RP-09	RP-000357	047		Movement of primitives text to the correct section	3.4.0	3.5.0
	RP-09	RP-000357	048		Corrections to RACH procedure	3.4.0	3.5.0
	RP-09	RP-000357	049		Clarification on the parameters of the MAC-RLC primitives	3.4.0	3.5.0
	RP-09	RP-000357	051	1	Editorial Cleanup	3.4.0	3.5.0
12/2000	RP-10	RP-000567	053	2	Corrections to logical channel priorities in MAC Protocol	3.5.0	3.6.0
	RP-10	RP-000567	055	1	Removal of FAUSCH	3.5.0	3.6.0
	RP-10	RP-000567	056	2	General MAC clarification	3.5.0	3.6.0
	RP-10	RP-000567	057	1	Error Handling in MAC	3.5.0	3.6.0
	RP-10	RP-000567	058	1	Error handling for MAC RACH and CPCH transmission control procedure	3.5.0	3.6.0
	RP-10	RP-000567	059		Inclusion of stage 3 for ciphering	3.5.0	3.6.0
03/2001	RP-11	RP-010025	061		Removal of FAUSCH	3.6.0	3.7.0
	RP-11	RP-010025	066	3	TFC selection algorithm correction	3.6.0	3.7.0
	RP-11	RP-010025	067	3	Miscellaneous corrections	3.6.0	3.7.0
	RP-11	RP-010025	068	2	Clarification on Traffic Volume Measurement Procedure	3.6.0	3.7.0
	RP-11	RP-010025	070	1	Clarification on parameters of the primitives	3.6.0	3.7.0
06/2001	RP-12	RP-010308	073	1	RLC Tr Discard	3.7.0	3.8.0
	RP-12	RP-010308	075	1	Clarification on compressed mode	3.7.0	3.8.0
	RP-12	RP-010308	077	1	Correction of relation between MAC functions and transport channels	3.7.0	3.8.0
	RP-12	RP-010308	079	1	Rate adaptation	3.7.0	3.8.0
	RP-12	RP-010308	081	1	Cleanup of MAC services and functions	3.7.0	3.8.0
09/2001	RP-13	RP-010541	084	1	Setting of UE Id in MAC	3.8.0	3.9.0
	RP-13	RP-010541	086		MAC ASC selection operation when access class is used to determine ASC	3.8.0	3.9.0

IPR2023-01272 Page 251

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
	RP-13	RP-010541	088	1	Addition of neighbour cell BCH to MAC-b model for the UE	3.8.0	3.9.0
	RP-13	RP-010541	092	2	Clarification on TFC selection	3.8.0	3.9.0
12/2001	RP-14	RP-010760	090	2	Cautionary Note for Interfrequency Measurements in Cell-FACH	3.9.0	3.10.0
	RP-14	RP-010760	094		Correction on Control of RACH Transmissions	3.9.0	3.10.0
	RP-14	RP-010760	096	1	Correction on Traffic Volume Control	3.9.0	3.10.0
	RP-14	RP-010760	098		General correction on Access Service Class selection	3.9.0	3.10.0
	RP-14	RP-010760	100		TFC selection in compressed mode	3.9.0	3.10.0
03/2002	RP-15	RP-020067	102	1	Clarification on ciphering	3.10.0	3.11.0
	RP-15	RP-020067	105		TDD MAC Layer Subchannel Assignment	3.10.0	3.11.0
	RP-15	RP-020067	109	1	Missing DTCH channel type in UE-ID Type Indicator	3.10.0	3.11.0
	RP-15	RP-020067	111	1	Correction on UE Id for DSCH	3.10.0	3.11.0
	RP-15	RP-020067	113		UE undefined behaviour when padding is required	3.10.0	3.11.0
06/2002	RP-16	RP-020326	115		Update References to include 25.123 (TDD)	3.11.0	3.12.0
	RP-16	RP-020326	118		TFCS selection guideline correction	3.11.0	3.12.0
09/2002	RP-17	RP-020538	128		MAC TVM Corrections	3.12.0	3.13.0
	RP-17	RP-020538	131		MAC header for DTCH and DCCH	3.12.0	3.13.0

IPR2023-01272 Page 252

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
11/974,381	10/12/2007	2112	1240	I-2-0526.2US	9	4

CONFIRMATION NO. 4314

CORRECTED FILING RECEIPT

24374
VOLPE AND KOENIG, P.C.
DEPT. ICC
UNITED PLAZA, SUITE 1600
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103

OC00000026812069

Date Mailed: 11/21/2007

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Applicant(s)

Philip J. Pietraski, Huntington Station, NY;
Gregory S. Sternberg, Mt. Laurel, NJ;

Assignment For Published Patent Application

InterDigital Technology Corporation, Wilmington, DE

Power of Attorney: The patent practitioners associated with Customer Number 24374

Domestic Priority data as claimed by applicant

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and claims benefit of 60/444,068 01/30/2003
and claims benefit of 60/470,921 05/15/2003
and claims benefit of 60/494,404 08/11/2003

Foreign Applications

If Required, Foreign Filing License Granted: 11/02/2007

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 11/974,381**

Projected Publication Date: 02/14/2008

Non-Publication Request: No

Early Publication Request: No

Title

Detection, avoidance and/or correction of problematic puncturing patterns in parity bit streams used when implementing turbo codes

Preliminary Class

714

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

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Title 37, Code of Federal Regulations, 5.11 & 5.15

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the **PATENT APPLICATION** of:	
Pietraski et al.	Our File: I-2-0526.2US
Application No.: 11/974,381	Date: November 15, 2007
Confirmation No.: 4314	
Filed: October 12, 2007	
For: DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	
Group: 2112	
Examiner: Not yet known	

REQUEST FOR CORRECTED FILING RECEIPT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Enclosed is a marked-up copy of the filing receipt for the above-identified patent application. Upon proofing, it was noted that the filing receipt is incorrect. There are two changes that need to be made.

With respect to Gregory S. Sternberg's address, please delete "Great Neck, NY" and insert therefor --Mt. Laurel, NJ--.

With respect to the title, please delete "party" and insert therefor --parity--.

Applicants respectfully request that a corrected Filing Receipt be issued.

Respectfully submitted,

Pietstraski et al.

By Scott Wolinsky
Scott Wolinsky
Registration No. 46,413
(215) 568-6400

Volpe and Koenig, P.C.
United Plaza, Suite 1600
30 South 17th Street
Philadelphia, PA 19103

SW/dt
Enclosure

UNITED STATES PATENT AND TRADEMARK OFFICE

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11/974,381	10/12/2007	2112	1240	I-2-0526.2US	9	4

CONFIRMATION NO. 4314

24374
VOLPE AND KOENIG, P.C.
DEPT. ICC
UNITED PLAZA, SUITE 1600
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103

FILING RECEIPT



Date Mailed: 11/08/2007

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Applicant(s)

Philip J. Pietraski, Huntington Station, NY;
Gregory S. Sternberg, ~~Great Neck, NY;~~ MT. LAUREL, NJ

Assignment For Published Patent Application

InterDigital Technology Corporation, Wilmington, DE

Power of Attorney: The patent practitioners associated with Customer Number 24374

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and claims benefit of 60/494,404 08/11/2003

Foreign Applications

If Required, Foreign Filing License Granted: 11/02/2007

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 11/974,381**

Projected Publication Date: 02/14/2008

Non-Publication Request: No

Early Publication Request: No

Title

Detection, avoidance and/or correction of problematic puncturing patterns in ~~party~~ PARITY bit streams used when implementing turbo codes

Preliminary Class

714

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Electronic Acknowledgement Receipt

EFS ID:	2471746
Application Number:	11974381
International Application Number:	
Confirmation Number:	4314
Title of Invention:	Detection, avoidance and/or correction of problematic puncturing patterns in party bit streams used when implementing turbo codes
First Named Inventor/Applicant Name:	Philip J. Pietraski
Customer Number:	24374
Filer:	Joseph P. Gushue/Diane Thatcher
Filer Authorized By:	Joseph P. Gushue
Attorney Docket Number:	I-2-0526.2US
Receipt Date:	15-NOV-2007
Filing Date:	12-OCT-2007
Time Stamp:	14:14:24
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Corrected Filing Receipt	Request_For_Corrected_Filing_Receipt.pdf	186718 0f438b3a5744168a34128df853f92e57f0c9b3ae	no	5

Warnings:	
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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

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If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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11/974,381	10/12/2007	2112	1240	I-2-0526.2US	9	4

CONFIRMATION NO. 4314

24374
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DEPT. ICC
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30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103

FILING RECEIPT

OC00000026591346

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Power of Attorney: The patent practitioners associated with Customer Number 24374

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APPLICATION NUMBER	FILING OR 371(c) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
11/974,381	10/12/2007	Philip J. Pietraski	I-2-0526.2US

CONFIRMATION NO. 4314

24374
VOLPE AND KOENIG, P.C.
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UNITED PLAZA, SUITE 1600
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Date Mailed. 11/08/2007

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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	I-2-0526.2US
First Inventor	Pietraski et al.
Title	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES
Express Mail Label No.	EV680555714US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. ☑ **Fee Transmittal Form** (e.g., PTO/SB/17)
   (Submit an original and a duplicate for fee processing)
2. ☐ **Applicant claims small entity status.** See 37 CFR 1.27.
3. ☑ **Specification** [*Total Pages* 43]
   Both the claims and abstract must start on a new page
   (For information on the preferred arrangement, see MPEP 608.01(a))
4. ☑ **Drawing(s)** (*35 U.S.C. 113*) [*Total Sheets* 12]
5. **Oath or Declaration** [*Total Sheets* 6]
   a. ☐ Newly executed (original or copy)
   b. ☑ A copy from a prior application (37 CFR 1.63(d))
   (for continuation/divisional with Box 18 completed)
   i. ☐ DELETION OF INVENTOR(S)
   Signed statement attached deleting inventor(s) name in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. ☑ **Application Data Sheet.** See 37 CFR 1.76
7. ☐ **CD-ROM or CD-R** in duplicate, large table or Computer Program *(Appendix)*
   ☐ Landscape Table on CD
8. **Nucleotide and/or Amino Acid Sequence Submission**
   (if applicable, items a. – c. are required)
   a. ☐ Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. ☐ CD-ROM or CD-R (2 copies); or
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   c. ☐ Statements verifying identity of above copies

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ACCOMPANYING APPLICATION PARTS

9. ☐ **Assignment Papers** (cover sheet & document(s))
   Name of Assignee_____
10. ☐ **37 CFR 3.73(b) Statement** *(when there is an assignee)* ☐ **Power of Attorney**
11. ☐ **English Translation Document** *(if applicable)*
12. ☐ **Information Disclosure Statement** (PTO/SB/08 or PTO-1449)
    ☐ Copies of citations attached
13. ☐ **Preliminary Amendment**
14. ☑ **Return Receipt Postcard** (MPEP 503)
    (Should be specifically itemized)
15. ☐ **Certified Copy of Priority Document(s)**
    (if foreign priority is claimed)
16. ☐ **Nonpublication Request** under 35 U.S.C. 122(b)(2)(B)(i). Applicant must attach form PTO/SB/35 or equivalent.
17. ☑ Other: Power of Attorney to Customer No. 24374 appears in Declaration.

18. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in the first sentence of the specification following the title, or in an Application Data Sheet under 37 CFR 1.76:*

☑ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No.: 10/725,779

Prior application information: *Examiner* Fritz Alphonse *Art Unit:* 2112

19. CORRESPONDENCE ADDRESS

☑ The address associated with Customer Number: 24374 ***OR*** ☐ Correspondence address below

Name	Volpe and Koenig, P.C., Dept ICC				
Address					
City		State		Zip Code	
Country		Telephone		Email	

Signature	Scott Wolinsky	Date	October 12, 2007
Name (Print/Type)	Scott Wolinsky	Registration No. (Attorney/Agent)	46,413

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Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).

FEE TRANSMITTAL
For FY 2008

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 1240

Complete if Known	
Application Number	Not Yet Known
Filing Date	Not Yet Known
First Named Inventor	Pietraski et al.
Examiner Name	Not Yet Known
Art Unit	Not Yet Known
Attorney Docket No.	I-2-0526.2US

METHOD OF PAYMENT (check all that apply)

☐ Check ☐ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): _____

☑ Deposit Account Deposit Account Number: 09-0435 Deposit Account Name: InterDigital Comm. Corp.

For the above-identified deposit account, the Director is hereby authorized to: (check all that apply)

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FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

Application Type	FILING FEES Fee ($)	FILING FEES Small Entity Fee ($)	SEARCH FEES Fee ($)	SEARCH FEES Small Entity Fee ($)	EXAMINATION FEES Fee ($)	EXAMINATION FEES Small Entity Fee ($)	Fees Paid ($)
Utility	310	155	510	255	210	105	1030.00
Design	210	105	100	50	130	65	
Plant	210	105	310	155	160	80	
Reissue	310	155	510	255	620	310	
Provisional	210	105	0	0	0	0	

2. EXCESS CLAIM FEES

Fee Description	Fee ($)	Small Entity Fee ($)
Each claim over 20 (including Reissues)	50	25
Each independent claim over 3 (including Reissues)	210	105
Multiple dependent claims	370	185

Total Claims	Extra Claims	Fee ($)	Fee Paid ($)
9 - 20 or HP =	0	x 0	= 0

HP = highest number of total claims paid for, if greater than 20.

Indep. Claims	Extra Claims	Fee ($)	Fee Paid ($)
4 - 3 or HP =	1	x 210.00	= 210

HP = highest number of independent claims paid for, if greater than 3.

Multiple Dependent Claims Fee ($)	Multiple Dependent Claims Fee Paid ($)
	0

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $260 ($130 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets	Extra Sheets	Number of each additional 50 or fraction thereof	Fee ($)	Fee Paid ($)
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SUBMITTED BY

Signature	Scott Wolinsky	Registration No. (Attorney/Agent) 46,413	Telephone 215-568-6400
Name (Print/Type)	Scott Wolinsky		Date October 12, 2007

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[0001] DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES

[0002] CROSS REFERENCE TO RELATED APPLICATIONS

[0003] This application is a continuation of U.S. Patent Application Serial No. 10/725,779, filed on December 2, 2003, which claims the benefit of U.S. Provisional Patent Applications Serial No. 60/434,232, filed on December 16, 2002, Serial No. 60/444,068, filed on January 30, 2003, Serial No. 60/470,921, filed on May 15, 2003, and Serial No. 60/494,404 filed on August 11, 2003, which are incorporated by reference as if fully set forth herein.

[0004] FIELD OF THE INVENTION

[0005] This invention generally relates to the use of Turbo codes in general, and, more particularly to a method for detecting and correcting performance degradation in punctured Turbo codes using a Turbo encoder.

[0006] BACKGROUND

[0007] Wireless communication systems are well known in the art. Generally, such systems comprise communication stations that transmit and receive wireless communication signals between each other. Typically, base stations are provided which are capable of conducting wireless concurrent communications with a plurality of subscriber stations. In Code Division Multiple Access (CDMA) systems specified by the Third Generation Partnership Project (3GPP), base stations are called Node Bs, subscriber stations are called User Equipments (UE) and the wireless interface between the Node Bs and UEs is known as the Uu interface. Figure 1 illustrates a typical 3GPP CDMA system.

[0008] The Uu radio interface of a 3GPP communications system uses Transport Channels (TrCH) for transfer of user data and signaling between UEs and Node Bs. In

3GPP Time Division Duplex (TDD) communications, TrCH data is conveyed by one or more physical channels defined by mutually exclusive physical resources. TrCH data is transferred in sequential groups of Transport Blocks (TB) defined as Transport Block Sets (TBS). Each TBS is transmitted in a given Transmission Time Interval (TTI) which may span a plurality of consecutive system time frames. A typical system time frame is 10 milliseconds and TTIs are currently specified as spanning 1, 2, 4 or 8 of such time frames.

[0009] Figure 2 illustrates the processing of TrCHs in TTD mode into a Coded Composite TrCH (CCTrCH) and then into one or more physical channel data streams in accordance with 3GPP TS 25.222 v3.8.0. Starting with the TB of data, Cyclic Redundancy Check (CRC) bits are attached and TB concatenation and code block segmentation is performed. Convolution coding or turbo coding is then performed, but in some instances no coding is specified. The steps after coding, include radio frame equalization, a first interleaving, radio frame segmentation and rate matching. The radio frame segmentation divides the data over the number of frames in the specified TTI. The rate matching function operates by means of bit repetition or puncturing and defines the number of bits for each processed TrCH which are thereafter multiplexed to form a CCTrCH data stream.

[0010] The processing of the CCTrCH data stream includes bit scrambling, physical channel segmentation, a second interleaving and mapping onto one or more physical channels. The number of physical channels corresponds to the physical channel segmentation. For uplink transmissions, UE to Node B, the maximum number of physical channels for transmission of a CCTrCH is currently specified as two. For downlink transmissions, Node B to UEs, the maximum number of physical channels for transmission of a CCTrCH is currently specified as sixteen. Each physical channel data stream is then spread with a channelization code and modulated for over air transmission on an assigned frequency.

[0011] In the reception/decoding of the TrCH data, the processing is essentially reversed by the receiving station. Accordingly, UE and Node B physical reception of

TrCHs require knowledge of TrCH processing parameters to reconstruct the TBS data. For each TrCH, a Transport Format Set (TFS) is specified containing a predetermined number of Transport Formats (TF). Each TF specifies a variety of dynamic parameters, including TB and TBS sizes, and a variety of semi static parameters, including TTI, coding type, coding rate, rate matching parameter and CRC length. The predefined collection of TFSs for the TrCHs of a CCTrCH for a particular frame is denoted as a Transport Format Combination (TFC).

[0012] Receiving station processing is facilitated by the transmission of a Transport Format Combination Indicator (TFCI) for a CCTrCH. 3GPP optionally provides for "blind transport format detection" by the receiving station, in which case the receiving station considers the potential valid TFCIs. Where there is only one valid TFCI, that TFCI is used in either case.

[0013] In 3GPP, time slot transmissions are made in predefined bursts where the transmitted physical channel data is divided into a beginning time slot portion and an ending time slot portion. A selected midamble is included between the two physical channel data portions. The TFCI is currently specified as transmitted in two parts on either side of the midamble and also between the two physical channel data portions. Two examples from 3GPP TR 25.944 V3.5.0 are illustrated in Figures 3 and 4 respectively where the block labeled MA represents the midamble and the block labeled T represents the parts of the TFCI. In Figure 4, the CCTrCH is mapped to two physical channels, but only one physical channel includes the TFCI.

[0014] Figures 5A, 5B and 6 are diagrams of channel coding and multiplexing examples in accordance with 3GPP Frequency Division Duplex (FDD) specifications.

[0015] The various encoding steps implemented in communication systems play a key role in both performance and capacity of a wireless telecommunications systems. In particular, the turbo coding of the data being processed for wireless transmission plays a significant role for both TDD and FDD communications in a 3GPP system.

[0016] Turbo coding principles have found widespread applications in information theory and, in part, have entered into mainstream telecommunication

theory and practice. These principles are used in error control, detection, interference suppression, equalization, and other communications-related areas. Turbo codes are a form of parallel, recursive systematic convolution codes, which can be used for channel coding and decoding in order to detect and correct errors that may occur in the transmission of digital data through different channels. Turbo codes are particularly useful for data transfers in which, under certain conditions, the data transfer rate can approach the theoretical limits of Shannon's Law. These favorable conditions generally include large block size transfers, which are particularly useful in mobile communications.

[0017] Figure 7 shows how particular codes created by puncturing exhibit poorer than expected performance. As much as a 4dB loss can be measured in the critical Signal-to-Noise Ratio (SNR) value.

[0018] Typically, high-rate Turbo codes are created by puncturing (i.e., eliminating) parity bits of a lower-rate code until the desired code rate is attained. Particular codes created by puncturing exhibit poorer than expected performance due to certain punctured bit patterns. Because the recursive encoding blocks in a Turbo encoder have an infinite impulse response, information about each systematic bit is distributed across many of the parity bits.

[0019] In any error control coding scheme that employs puncturing, the location of the punctured bits will have an impact on performance. This is because puncturing strings of successive bits can be viewed as burst errors by the decoder. All error control mechanisms can only correct burst errors that are less than some threshold. Therefore, it is important when designing the puncturing scheme that the burst error correcting abilities of the code be considered. In the absence of specific knowledge of the error control coding scheme, a good rule is to minimize the maximum string of punctured bits. For high coding rates this corresponds to distributing the non-punctured bits uniformly across the transmitted block. Puncturing schemes that uniformly distribute the non-punctured bits can deleteriously interact with certain error control codes, causing a degradation of decoder performance.

[0020] Because the recursive encoding blocks in the Turbo encoder have infinite impulse response, information about each systematic bit is distributed across many of the parity bits. The impact of certain periodic non-puncture patterns in the parity bits can be qualitatively illustrated by considering how much information remains in the surviving parity bits.

[0021] Regions where performance of the punctured Turbo code is degraded can be determined by measuring how close the puncturing pattern is to being periodic with period related to the period of the semi-periodic impulse response of the recursive encoding blocks of the Turbo encoder.

[0022] For a 3GPP Turbo encoder, the constituent recursive encoders have an impulse response that is periodic with a period of 7 symbols for positive time (semi-periodic). This can readily be seen by interpretation of the encoder as an M-sequence generator, i.e., if the shift register starts in the zero state and a one is applied only at $t = 0$, then the encoder is exactly a Linear Feedback Shift Register (LFSR) with an associated 3rd order primitive polynomial and initial state {1 0 0}, thus a period $2^3-1 = 7$ M-sequence is generated for positive time.

[0023] The encoder is a Linear Time Invariant (LTI) system on a binary field. Therefore, the output of the encoder is a sum of shifted versions of the impulse response of the encoder, each shifted impulse response corresponding to the locations of the 1's in the TB. If we consider an input that is all 0's for $t > T$, then the output of the constituent recursive encoding block will also be semi-periodic for $t > T$.

[0024] Certain non-puncturing periods may result in a loss of distributed information about a small group of bits across the set of parity bits. For example, let the TB consist of 7 bits followed by many zeros. Now consider the problem of trying to determine the seven bits by observation of the output of one encoder after heavy puncturing. Each observation is made at the output is a sum of a subset of the 7 bits, the subset being determined by the non-puncture period and the impulse response of the recursive encoding block. For most non-puncture patterns (those that have a period relatively prime with the period of the semi-periodic impulse response), sums

over 7 different subsets can eventually be observed. Therefore, a system of 7 equations with 7 unknowns can be formed. Assuming they are linearly independent, the values of the 7 bits may be determined. However, consider the case where the non-puncture period is simple (one surviving parity bit per period) and the same as the period of the recursive encoding block, 7. Then every observation for $t > 6$ is the sum of the same subset of the 7 bits and so no new information is obtained, i.e., a rank-1 system of equations is formed and a unique solution does not exist. This is due to the periodic nature of the signal. When the non-puncture period is relatively prime with the period of the recursive encoding block, a series of observations of the parity bits will eventually form a rank-7 system of equations. For our 7-bit group, this is sufficient to uniquely determine the bits, i.e., information sufficient to determine the bits is distributed across the surviving parity bits. When the periods are not relatively prime, the rank of the system becomes L/K where L is the period of the recursive encoding block and K is the Greatest Common Divider (GCD) of L and N where N is the period of the non-puncture pattern.

[0025] In the above illustration, a long sequence of zeros after the small group of bits was supposed for clarity sake. However, allowing additional groups of bits to follow the first group does not add to the distributed information about earlier groups. This can be seen from the causality of the system.

[0026] It is also possible that some distributed information is lost even for non-simple periods, e.g., consider the case where the non-puncture pattern alternates between a simple period of three and four. This results in a period 7 non-puncture pattern but with two surviving parity bits per period. The same argument above leads to a rank-2 system of seven equations which is still insufficient to uniquely determine the group of bits, but does reduce the dimension of the space they may span. Clearly, some information about the small group of bits is lost for some non-punctured patterns.

[0027] In order to obtain adequate performance, it is necessary to detect, avoid and/or correct the problematic puncturing patterns in the parity bit streams without

having to avoid code rates. Typically, problematic interactions occur between the Turbo coder output and puncturing in the rate matching stages.

[0028] It would be desirable to have a method for creating high-rate Turbo codes that avoids problematic interactions by modifying the puncturing patterns.

[0029] SUMMARY OF THE INVENTION

[0030] According to the present invention, degradations in quality of punctured error correction coded transmissions are identified and the code transmissions are modified accordingly. A puncturing pattern which approximates a particular code rate is identified, and a value for anticipated degradation is adjusted in accordance with a matching of the puncturing pattern and the particular code rate.

[0031] For both FDD and TDD, two stages of rate matching and two puncturing operations are included, and this is done because of a certain technique called, incremental redundancy, which allows for a wireless transmit/receive unit (WTRU) to receive and soft combine multiple transmissions of the same TB from the base station. If the transmission fails the first time, the signal is retransmitted with more data in an attempt to obtain a successful communication the second time. In order to do that, two different stages of puncturing are used because the WTRU has certain capabilities, certain buffer sizes that it can support, and in order to be able to fit the retransmissions that are combined into the buffer, there are two stages of puncturing. The first stage of rate matching punctures enough bits such that the surviving bits fit into a buffer, and the second stage of puncturing (or repetition) is to achieve the desired overall code rate. When the two stages of rate matching are combined, a plot of problematic regions of coding rate is a multidimensional plot. Thus, there are two rates now involved, which are a rate in a first stage of puncturing and a rate in a second stage of puncturing.

[0032] According to a first embodiment of the present invention, P1/P2 puncturing biasing for a single stage of rate matching is implemented using the punctured error correction coded transmissions.

[0033] According to a second embodiment, two or more stages may be employed at each stage of rate matching for detecting and correcting performance in punctured Turbo codes on a High Speed Downlink Shared Channel (HS-DSCH) in R5 High Speed Downlink Packet Access (HSDPA).

[0034] BRIEF DESCRIPTION OF THE DRAWINGS

[0035] A more detailed understanding of the invention may be had from the following description of a preferred embodiment, to be understood in conjunction with the accompanying drawing wherein:

[0036] Figure 1 is a schematic diagram of a typical CDMA system in accordance with current 3GPP specifications;

[0037] Figure 2 is a processing diagram of TrCH data for a CCTrCH in accordance with 3GPP TDD specifications;

[0038] Figures 3 and 4 are diagrams of channel coding and multiplexing examples in accordance with 3GPP TDD specifications;

[0039] Figures 5A, 5B and 6 are diagrams of channel coding and multiplexing examples in accordance with 3GPP FDD specifications;

[0040] Figure 7 shows typical results of particular codes being created by puncturing, where as much as 4 dB loss can be measured in critical SNR value;

[0041] Figure 8 graphically depicts the SNR required to successfully decode a data block (critical SNR) with high probability vs. Code Rate when P1/P2 biasing is applied;

[0042] Figure 9 is a plot of the problematic regions with respect to an ordered pair (r1,r2) which are the rates of puncturing the parity streams in the first and second stages of rate matching, respectively;

[0043] Figure 10 is a schematic block diagram showing a circuit for 3GPP rate matching for HSDPA, using a Turbo coded HS-DSCH; and

[0044] Figure 11 graphically depicts initial Block Error Rate (BLER) for HS-DSCH transport blocks with certain effective coding rates.

[0045] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0046] In accordance with the present invention, several methods and embodiments are disclosed for detecting, avoiding and/or correcting the problematic puncturing patterns in the parity bit streams without having to avoid code rates.

[0047] The present invention is potentially applicable to layers 1 and 2 in a FDD, CDMA 2000 and TDD Universal Mobile Telecommunications System (UMTS) modes of transmission as well as other modes of transmission. Additionally, methods are described hereinafter for modifying the puncturing patterns such that performance of degraded Turbo code is restored.

[0048] In accordance with the present invention, the methods disclosed herein may be implemented in a wireless transmit/receive unit (WTRU) and/or a base station. Hereinafter, a WTRU includes but is not limited to a UE, mobile station, fixed or mobile subscriber unit, pager, or any other type of device capable of operating in a wireless environment. When referred to hereafter, a base station includes but is not limited to a base station, Node-B, site controller, access point or other interfacing deice in a wireless environment.

[0049] Figure 8 graphically depicts the SNR required to successfully decode a data block (critical SNR) with high probability versus Code Rate when biasing of parity bits P1/P2 is applied. As shown in Figure 7, it has been found that particular codes created by puncturing the rate 1/3 3GPP Turbo code exhibit poorer than expected performance, as can be seen from the peaks in the figure.

[0050] Figure 9 is a plot of the problematic regions with respect to an ordered pair (r1,r2) which are the rates of puncturing the parity streams in the first and second stages of rate matching, respectively. As can be seen, there are particular regions where the rates of puncturing of the parity streams are such that some combinations of rates are particularly problematic.

[0051] In one embodiment, puncture biasing for parity bits P1 and P2 is implemented for one stage rate matching. Figure 10 is a schematic block diagram showing circuitry 600 for 3GPP rate matching for HSDPA, using a Turbo coded

HS-DSCH. The circuitry 600 implements a 3GPP rate-matching scheme for HSDPA. The circuitry 600 includes a bit separation circuit 605, a first rate matching stage 610, a virtual incremental redundancy (IR) buffer 615, a second rate matching stage 620 and a bit collection circuit 625. The first rate matching stage 610 includes a Parity 1 (P1) bit rate matching circuit 630 and Parity 2 (P2) bit rate matching circuit 635. The second rate matching stage 620 includes a systematic bit rate matching circuit 640, a Parity 1 (P1) bit rate matching circuit 645 for the second rate matching and a Parity 2 (P2) bit rate matching circuit 650 for the second rate matching. In operation, the systematic bits, Parity 1 (P1) and Parity 2 (P2) bits are processed through the first rate matching stage 610, virtual IR buffer 615, second rate matching stage 620 and bit collection circuit 625. Note that the Parity 1 (P1) and Parity 2 (P2) bits are treated separately. The systematic bits, Parity 1 (P1) and Parity 2 (P2) bits are combined at the bit collection circuit 625 to provide a single data output N_{data}. Also note that if the number of coded bits is less than or equal to the size of the virtual IR buffer 615, the first rate matching stage 610 is transparent. The transparent first stage case and Rel-4 rate matching are considered.

[0052] In its actual implementation, it is anticipated that the different circuit functions will be executed by a common circuit or circuits, such as microprocessor circuitry, and in accordance with program instructions. The specific circuit functions used to implement the invention would therefore be a matter of choice of those configuring the circuitry within the rate matching circuitry 600.

[0053] The rate matching algorithm performs puncturing if the overall code rate is greater than 1/3 and repetition if the code rate is less than 1/3. Currently code rates greater than 1/3 are accomplished by applying the same puncturing rate to both P1 and P2 bits (to within one bit) but with different puncturing pattern phases. In order to avoid non-puncturing periodicities that have been shown to degrade the Turbo code performance, the puncturing rates for P1 and P2 be independently biased. For example, if the number of P1 bits is decreased by Δ and the number of P2 bits is increased by Δ, the overall code rate is unchanged but the problematic non-puncturing

periods can be avoided. Given this approach to avoiding the problematic code rates, an analytical expression for the requisite bias, has been derived.

[0054] A simple and efficient method of modifying the puncture patterns is biasing the number of punctured bits in P1 and P2 by adding additional puncturing to one and removing it from the other. The amount of the bias should be no more than is needed to avoid certain periodicities. In biasing the puncturing rates of P1 and P2 bits, two constraints must be met.

[0055] When non-puncturing patterns with period $7\hat{N}/2$ ($\hat{N} = 1, 2, 3\ldots$) are used, degradation in performance results. These non-puncturing patterns periods will be employed whenever the average non-puncturing period of P1 or P2 bits is within ±1 or ±½ of $7\hat{N}/2$ for even and odd $\hat{N}$ respectively.

[0056] The average non-puncturing rate of the P1 and P2 rate matching blocks is $I/(P/2)$ where I is the number of bits at the input to each branch of rate matching and P is the total number of parity bits (P1 and P2) at the output of rate matching. Therefore, the desired code rate will lead to a problematic puncturing pattern if,

$$\left|\frac{I}{(P/2)}-\frac{7\hat{N}}{2}\right|<1-\frac{\hat{N}}{2}+\left\lfloor\frac{\hat{N}}{2}\right\rfloor, \qquad \text{Equation 1}$$

for $\hat{N}>0$ where,

$$\hat{N}=\left\lfloor\frac{4I}{7P}+\frac{1}{2}\right\rfloor. \qquad \text{Equation 2}$$

[0057] In biasing the puncturing rates of the parity bit streams 1 and 2, P1 and P2, two constraints must be met.

[0058] First, the number of surviving bits in parity bit stream 1 must be increased sufficiently by an amount Δ to avoid the problematic puncturing patterns. Second, the number of surviving bits in parity bit stream 2 must be decreased by an equal amount Δ that is also sufficient to avoid problematic puncturing patterns.

[0059] These two constraints can be combined in to the following expression for Δ, where:

[0060] $$\Delta = \left\lceil \max\left\{ \left(\frac{I}{\left\lfloor \frac{7\hat{N}-1}{2} \right\rfloor} - \frac{P}{2} \right), \left(\frac{P}{2} - \frac{I}{\left\lceil \frac{7\hat{N}+1}{2} \right\rceil} \right) \right\} \right\rceil \quad \text{Equation 3}$$

[0061] Alternatively, non-punctured bits may be increased in P2 and decreased in P1. The procedure to determine and apply the necessary P1/P2 bias is as follows:

Step 1) Compute $\hat{N}$ using Equation 2.

Step 2) Determine if the desired code rate results in a problematic puncturing pattern using Equation 1. If it does, continue to Step 3, otherwise set $\Delta = 0$ (if $\left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right| \geq 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor$).

Step 3) Compute the bias Δ using Equation 3.

Step 4) Compute rate matching parameters by modifying Table in TS25.212/222.

[0062] In order to avoid puncturing patterns that degrade Turbo code performance, the amount of puncturing applied to parity bit streams 1 and 2 respectively could be slightly different, while keeping the overall number of punctured bits constant.

[0063] If the number of punctured bits in parity bit stream 1 is decreased by Δ and accordingly, the number punctured bits in parity bit stream 2 bits is increased by Δ, the overall code rate is unchanged, but the problematic puncturing patterns can be avoided. Note that bit collection and bit de-collection stages need to be adjusted correspondingly for this case. Since individual regions of degraded performance tend to be small, it may be advantageous to simply avoid the use of code rates with degraded

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performance. Since code rates with degraded performance can now be identified using the above equation, it is a simple matter to avoid them.

[0064] For Hybrid Automatic Repeat reQuest (HARQ) as deployed in 3GPP, it may be necessary to employ two stages of rate matching. This occurs whenever incremental redundancy (IR) is employed and the number of bits input to the rate-matching algorithm is larger than the virtual IR buffer. Note that when Chase combining HARQ is used, there is no need for a special IR buffer; a received bit buffer would be sufficient. (If constellation rearrangement were not used, a buffer of received symbols would be sufficient.) If it is determined that IR provides only a small improvement over Chase combining, then removal of IR from the standards may be advisable.

[0065] In order to obtain higher data rates, the 3GPP has introduced the HSDPA option wherein link adaptation is performed. One component of the link adaptation is Adaptive Modulation and Coding (AMC). With AMC, a channel quality estimate is used to select the modulation type and code rate that attains the largest throughput. When the channel quality is high, QAM modulation and a high code rate are selected. High code rates are obtained by puncturing a rate 1/3 Turbo code. During the design of the channel quality indication (CQI) table, it was observed that certain Transport Block Set Sizes (TBSS) exhibited poorer than expected performance. The CQI table is used to map a channel quality estimate into a recommended modulation and TBSS. This problem of poorer than expected performance is currently addressed by simply "hand tweaking" the CQI table to avoid the TBSSs that cause problems. In AMC, this leads to less than optimal throughput since optimal code rates will inevitably be avoided.

[0066] Support for link adaptation by means of AMC is an integral feature of R5 HSDPA. With AMC, modulation type and code rate on HS-DSCH can be varied according to channel conditions. Variable coding rates on HS-DSCH are achieved by means of rate matching (repetition or puncturing) output of the R99 Turbo-coder in a pre-determined manner, i.e. as a function of TBSS and available number of Physical

Channel bits. Both R99/R4 and R5 use the same code rate 1/3 Turbo-coder. While the principle of rate-matching is the same for both R4 and R5, the likely and more frequent use of higher effective code rates (>1/2), the use of multiple stages of rate matching, and the standard allowing for the possibility of Incremental Redundancy (IR) differentiate R99/R4 and R5.

[0067] HSDPA performance requirements in WG4 have indicated unusually high and rather unpredictable SNR performance degradations for Turbo-coded and punctured transport blocks on HS-DSCH up to several dB for a range of effective coding rates above 1/2.

[0068] The Turbo-coding performance on HS-DSCH is heavily impacted by unfavorable puncturing patterns of the parity bit streams output by the baseline rate 1/3 Turbo-coder. Although the original WG4 simulation results were provided in a TDD-context, exactly the same degradations also occur in FDD, the reason being that Turbo-coding and rate-matching (TS25.212 and TS25.222) on HS-DSCH transport blocks (where the problematic interactions originate) are done exactly the same way for both modes.

[0069] The poorer than expected performance at some data rates is also a problem with a fixed modulation and coding scheme. If a user is assigned a code rate that exhibits the problem, the poor performance of the code will be compensated for by power control thus reducing cell capacity.

[0070] In another embodiment, adjustments to the parity stream puncturing allows the Medium Access Control – High Speed (MAC-hs) to simply select any desired transport block size as an outcome of the scheduler decision. It would be required to slightly change the generation of the puncturing patterns in the rate-matching stages in TS25.212/222. For example, one implementing modification to the current FDD standard as set for in TS 25.212 is appended hereto along with a brief discussion of why the modification is desirable.

[0071] For both the case of 1st rate-matching stage being transparent and the case of both 1st and 2nd rate-matching stage being employed, a number of acceptable

solutions exist to avoid the problematic interactions by means of adjustments to the parity bit puncturing.

[0072] One of these solutions, e.g. a simple biasing method, is outlined below in the interest of providing a conceptual example for the case of the 1st rate-matching stage being transparent.

[0073] Currently, coding rates >1/3 are accomplished by applying the same amount of puncturing to both parity bit streams 1 and 2 at the output W of the Turbo-coder (Figure 10), although the puncturing pattern "phases" can be adjusted.

[0074] When a particular code rate is desired and it is determined that its use will result in degraded performance, a slightly lower code rate may be selected to avoid the degradation. Good choice for the substituted code rate would be the largest allowable code rate less than the desired code rate that has been determined to have an acceptable degradation.

[0075] If it is desirable for a system to be allowed to make unrestricted use of available code rates, then performance may be restored by modification of the puncture pattern. The key to restoring performance to the punctured Turbo code is to avoid the case where the surviving parity bits are overly redundant with respect to the systematic bits, i.e., modify the puncturing pattern to improve performance. One way to accomplish this is to sample the parity bits such that all the points corresponding to one complete period of the semi-periodic impulse response are sampled with as few samples as possible while maintaining the same code rate and not overly distorting the uniformity of the puncturing over the data block or creating overly large imbalances in the number of surviving parity bits in P1 and P2.

[0076] It should also be noted that this method of mitigation could also be applied to systems with more than 2 parity streams. For example, the 3GPP Turbo code (CDMA 2000) includes four parity streams. If a problematic puncturing pattern occurs it can be alleviated by adjusting the puncturing rates of each of the individual parity streams while maintaining a constant overall effective coding rate.

[0077] In the case of single stage of rate matching, as used in R99/R4 and in many R5 configurations, the problematic interactions between the Turbo-coded output and the punctured transmitted sequence occurs in regions where the puncturing patterns are nearly periodic with surviving bit period equal to a multiple of 7, and when an average 1 out of every 3.5 parity bits survive.

[0078] These degradations correspond to rank-1 and rank-2 scenario respectively. This case corresponds to the rank-1 scenario. Rank-2 scenarios have less impact on the SNR degradation than rank-1 scenarios. Since higher rank scenarios (>2) do not significantly contribute to performance degradation, ranks other than rank-1 and rank-2 scenarios are not considered here.

[0079] The code rates at the center of these regions are determined by:

[0080] $$CR = \frac{1}{1+\frac{2}{3.5N}} = \frac{3.5N}{3.5N+2} \qquad N = 1,2,... \qquad \text{Equation 4}$$

[0081] The critical code rate, *CR*, corresponds to a rank-1 scenario when N is even and rank-2 when N is odd. For rank-1, we have critical code rates *CR* = 7/9, 7/8, 21/23,... and for rank-2, we have *CR* = 7/11, 21/25,....

[0082] The ratio of the number of systematic bits and the number of parity bits in either parity bit stream 1 or 2 can be considered as "parity puncturing rate". When surviving bit patterns with parity puncturing rate close or equal to $7N/2$ (N =1,2,3...) are used, degradation in performance results. Some amount of Turbo-coding and puncturing interaction will also occur whenever the average periodicity of surviving bits of the parity bit streams 1 or 2 is within ±1 or ±½ of $7N/2$ for even and odd N respectively.

[0083] When two (or more) stages of rate matching are employed, problematic puncturing patterns can be generated by any stage, or by the interaction between the stages of rate matching.

[0084] A closed form expression(s) has been developed for the Release 5 3GPP Turbo coder / Rate Matching that predicts the performance degradation. The

expression takes as input either the triplet {Bits Before 1st stage of rate Matching, Max Bits after 1st Rate Matching, Bits after 2nd Rate matching} or the pair {Rate of 1st stage Rate Matching with respect to parity bits, Rate of 2nd stage Rate Matching with respect to parity bits}. The output, as depicted in Equation 5 below, is a rational number that may be compared to a threshold to accept/reject the configuration as providing/not providing acceptable performance. The parameters *r1* and *r2* represent the rates associated with the 1st and 2nd stages of rate matching with respect to the parity bit streams. Although complicated, the Equation 5 is a piecewise linear and continuous function in r1, r2 and is therefore trivial to evaluate.

$$\begin{aligned}\lambda(r1,r2)=\sum_{n=1}^{L-1}\alpha_n\Bigg[&\left(1-\left\lceil\frac{1}{L}\lceil r1\lceil nr2\rceil\rceil-\left\lfloor\frac{1}{L}\lceil r1\lceil nr2\rceil\rceil\right\rfloor\right)(nr2-\lfloor r2\rfloor)(r1\lceil nr2\rceil-\lfloor r1\lceil nr2\rceil\rfloor)+\\&\left(1-\left\lceil\frac{1}{L}\lfloor r1\lceil nr2\rceil\rfloor-\left\lfloor\frac{1}{L}\lfloor r1\lceil nr2\rceil\rfloor\right\rfloor\right)(nr2-\lfloor nr2\rfloor)(-r1\lceil nr2\rceil-\lfloor r1\lceil nr2\rceil\rfloor+1)+\\&\left(1-\left\lceil\frac{1}{L}\lceil r1\lfloor nr2\rfloor\rceil-\left\lfloor\frac{1}{L}\lceil r1\lfloor nr2\rfloor\rceil\right\rfloor\right)(-nr2+\lfloor nr2\rfloor+1)(r1\lfloor nr2\rfloor-\lfloor r1\lfloor nr2\rfloor\rfloor)+\\&\left(1-\left\lceil\frac{1}{L}\lfloor r1\lfloor nr2\rfloor\rfloor-\left\lfloor\frac{1}{L}\lfloor r1\lfloor nr2\rfloor\rfloor\right\rfloor\right)(-nr2+\lfloor nr2\rfloor+1)(-r1\lfloor nr2\rfloor+\lfloor r1\lfloor nr2\rfloor\rfloor+1)\Bigg]\end{aligned}$$

Equation 5

[0085] A threshold comparison could then be based on this equation to test whether or not the Code Rate pair will perform adequately. Equivalently, the triple: {Data Block Size, Size After 1st Stage Rate-Matching, Size After 2nd Stage Rate-Matching} can be used since this triple maps directly into the Code Rate pair.

[0086] The effect of the periodicity of the puncturing pattern can also be mitigated by interleaving the parity bits before rate-matching occurs. In this way, after de-interleaving, periodic sampling of the parity bits is avoided even when periodic sampling is done in rate-matching.

[0087] The functionality of the channel interleaver can be incorporated into the rate-matching block interleaver. This can be accomplished by adding additional constraints to the rate-matching block interleaver (those defined by the channel

interleaver) when the interleaver is designed. This however will require an additional interleaver for the systematic bits.

[0088] Note that the rearrangement of the non-punctured bits only needs to occur on a range equal to the period of the semi-periodic impulse response of the recursive encoding blocks of the Turbo encoder. Therefore, small time-varying interleavers can be added to the parity bit steams to prevent problematic puncturing patterns. This has the advantage of requiring less memory and helps to minimize the distortion of the uniformity of the puncturing.

[0089] Certain parameters may be made to vary as a function of time (or bit index) to generate puncturing patterns that will mitigate performance degradations. One such example for 3GPP includes modification of the rate-matching parameters X_i, e_ini, e_minus and e_plus parameters throughout the execution of the rate-matching. In this way, the parameters affecting the puncturing pattern may change at one or more locations within the block of bits being punctured. By allowing the parameters to change, the instantaneous code rates may be different from the desired overall code rate (thereby avoiding the puncturing interaction) while still maintaining the same overall code rate. For example: 1) e_plus and e_minus may change frequently throughout the puncturing algorithm thus breaking up any possible long runs of deleterious puncturing. 2) Parameters may be changed so that the code rate is changed so that it is higher in some portions of the code block and lower in others.

[0090] The above methods are examples of modifications to the puncturing pattern used to generate specific code rates. All such methods may be considered special cases and specific implementations of the more general concept of a permutation of the puncturing pattern. Any method of changing the puncturing pattern, i.e., generating some permutation of the original puncturing pattern, has the potential of changing the overall performance of a code.

[0091] One can achieve the desired overall code rate while avoiding problematic puncturing patterns by adjusting the amount of puncturing performed in each stage. This method, when placed in the context of the 3GPP HSDPA Turbo Code / Rate

Matching algorithm leads to artificially reducing the size of the virtual Incremental Redundancy (IR) buffer. In general the approach implies a modification to the individual puncturing rates of each of the stages such that a desirable overall puncturing pattern results.

[0092] Stage Rate Biasing is easily accomplished by changing the operating point (the *r1*, *r2* pair) to some point on a curve of constant code rate (i.e., where the product *r1*r2* is unchanged) where performance degradation is tolerable.

[0093] The combination of adjusting the stage puncturing rates as well as the relative rates of puncturing in the two parity streams can also mitigate the problematic interaction between the puncturing pattern and the Turbo Code performance.

[0094] This can be envisioned as splitting the operating point into two points. One of the points corresponds to the rates of 1st and 2nd stage rate matching for the first parity bit stream and the second point for the second parity bit stream. The two points should be selected so that the overall code rate is unchanged, both points lie in regions of acceptable performance, and the total number of surviving bits after the first stage of rate matching does not exceed imposed limits such as an IR buffer.

[0095] The present invention provides several simple and efficient techniques of detecting, avoiding and/or correcting problematic puncturing patterns in the parity bit streams without having to avoid desired code rates. According to the present invention, degradations in punctured error correction coded transmissions are reduced by identifying a puncturing pattern which approximates a particular code rate, and adjusting a value for anticipated degradation in accordance with the matching of the puncturing pattern and the particular code rate.

[0096] When creating high rate codes via puncturing, it is generally desirable to distribute, as uniformly as possible, the bits that are punctured. Using this guideline, it is inevitable that certain code rates will require the resulting non-punctured bit pattern to be less effective. One such example occurs when the non-punctured bit pattern is periodic, with a period equal to the period of the semi-periodic impulse

response of the recursive encoding blocks of the Turbo encoder. An algorithm may used to identify all puncturing patterns with degraded performance.

[0097] In a particular embodiment of the invention, the capacity of a WTRU is determined, including buffer sizes that are supported by the WTRU. The puncturing is used to reduce the number of bits to fit into the buffer, and the overall code rate is adjusted so as to provide sufficient error correction capability. This provides a first rate in a first stage of puncturing and a second rate in a second stage of puncturing.

[0098] According to the present invention, detecting, avoiding and/or correcting problematic puncture patterns in parity bit streams and punctured Turbo codes is achieved without having to avoid desirable code rates. This is applicable without limitation, to FDD, TDD and other modes of transmission, and enables identification/avoidance of regions of relatively poor Turbo code performance, which might result from the prior art bit-puncturing scheme. The invention provides for forward error correction comprising Turbo coding and puncturing that achieve a smooth functional relationship between any measure of performance and the effective coding rate resulting from combining the lower rate code generated by the Turbo encoder with puncturing of the parity bits. Examples of measures of performance would be BLER, bit error rate (BER), required signal-to-interference ratio (SIR), or required SNR.

[0099] The patterns of the puncturing are created by creating an encoded transmission at a particular data rate and excluding some of the encoded bits. At the receiver end, zeros or other "filler" bits are put in place of the punctured bits, and the decoding operation is based on the received signal with the missing bits. According to the present invention, the puncturing pattern is modified in order to eliminate degradation which would occur under particular puncturing patterns. In particular, if the puncturing pattern is regular or has a periodic nature, it is more likely to result in signal degradation. By eliminating the degradation, it is possible to achieve the desired code rate.

[0100] The present invention is particularly useful for 3GPP-coding, and can be used for low chip rate TDD, high chip rate TDD and FDD.

[0101] One such example of a periodicity occurs when the non-punctured bit pattern is periodic with period equal to the period of the semi-periodic impulse response of the recursive encoding blocks of the Turbo encoder. An algorithm is provided to identify all puncturing patterns with degraded performance. Additionally, modification of the puncturing patterns is performed such that performance of the Turbo code is restored.

[0102] Modifications to puncturing are used to restore Turbo performance. If it is desirable for a system to be allowed to make unrestricted use of available code rates, then performance may be restored by modification of the puncture pattern. Therefore if it is deemed desirable for a system to be allowed to make unrestricted use of available code rates, then performance may be restored by modification of the puncture pattern.

[0103] Adaptive coding means that on the fly, information is obtained from the WTRU that indicates the channel quality. Based on that, the transmitter adjusts its code rate amongst other parameters. In instances of poor reception, a substantial amount of redundancy is added, which results in a very low code rate, but which allows transfer of data through with the required block error probability.

[0104] The channel quality estimation procedure does not inherently take into account the possibility that problematic puncturing may have been used, nor should it. The channel quality is typically based on signal power and noise power, but it does not take into account the fact that the encoder may have been punctured in a problematic way, therefore AMC will not serve to avoid problematic code rates. With good channel quality, very little coding is needed and it is possible to use a higher order modulation. If the channel quality is poor, the code rate is reduced. Therefore, a reduced data rate is used to provide the desired error performance. The channel quality indicator is used to monitor the channel quality and in turn provides input to the data rate controller.

[0105] Capacity is measured by determining a combined data rate to all users supported. If one or more users in a cell are tuned to a problematic code rate, then those users are presumed to require more power and thereby reduce capacity. In many cases the problematic coding rates are known or can be determined via this invention and therefore it is possible to avoid these rates.

[0106] The present invention provides an ability to identify problem rates in advance through some analytical means, and responding to this information by avoiding these rates either dynamically or statically. This can be achieved by detecting problematic patterns or by using a formula or table of rates to avoid. If a transmission calls for one of the problem rates, the actual transmission is provided at a rate which is slightly different. The result is, the problem rate is avoided.

[0107] These are representative examples of modifications to the puncturing pattern used to generate specific code rates, as applicable to layer 1 and layer 2 in the TDD and FDD mode of transmission in accordance with the present invention. Variations to the examples described are conceivable. All such variations may be considered special cases and specific implementations of the more general concept of a permutation of the puncturing pattern. Any method of changing the puncturing pattern, i.e., generating some permutation of the original puncturing pattern, has the potential of changing the overall performance of a code, and it is the intent to include permutations and methods of generating such permutations of the puncturing pattern envisaged in the present invention. All modifications and improvements to the basic concept of the invention as set forth hereinabove are envisaged to be within the ambit of the present invention.

[0108] Figure 11 shows the BLER performance of 3 different HS-DSCH transport blocks of increasing size 4554, 4705 and 4858 bits respectively. All of them are rate 1/3 Turbo-coded, and then punctured down to 6072 bits mapped to the High Speed Physical Downlink Shared Channels (HS-PDSCH). This results in an effective coding rate of 0.75 (labeled 7/9-), 0.77 (labeled 7/9) and 0.80 (labeled 7/9+) for the 3 increasing transport blocks sizes.

[0109] When increasing the effective coding rate (or equivalently increasing the puncturing rate) of a Turbo-coded transport block on HS-DSCH, one should expect that BLER performance degrades in a proportioned manner, i.e. gets increasingly worse for increasingly higher effective coding rates. This unfortunately does not always happen, and it can be seen in this example that the rate 0.77 (7/9) coded transport block needs some 3dB more SNR than a rate 0.80 coded transport block to achieve the same BLER of approximately 10%.

[0110] The reason for the observed degradations is that the periodicity (period = 7) in the output of the two Turbo-coder parity bit streams, as given by the impulse responses of the constituent recursive convolutional encoders, deleteriously interacts with the periodicity of the puncturing patterns applied by the second and/or the first rate matching stages in many cases. This effect is increasingly more frequent for increasingly higher puncturing rates.

[0111] In the analyses that follow, a single R99 rate-matching block is assumed. However, the concepts apply more generally to R4 and R5 with and without incremental redundancy. The main conclusion for both cases is that the critical puncturing rates leading to SNR degradation are predictable in principle, but would require a rather complex set of parameters to be taken into account.

[0112] The setting of critical puncturing rates is avoided in the MAC-hs in the Node B, which has the particular advantage that it would not require a change in current standards and could leave details open to vendor-specific implementation. While this approach is preferable, the look-up tables used are complex and restrictions on possible MAC-hs scheduler decisions are imposed.

[0113] Alternatively, slight modifications are made to the puncturing patterns as generated by the current rate-matching stages for HS-DSCH in TS25.212/222. These modifications constitute only a small change in the way the rate matching parameters are generated in TS25.212/222, e.g., parameters for HARQ second rate matching, and more importantly do not require any additional signaling.

[0114] Due to the apparent simplicity of the second option (slight modification of the generation of the puncturing pattern on Turbo-coded parity bit streams) and its transparency for the MAC-hs scheduler (simply selects whatever transport block size is desired as outcome of the scheduler decision), a corresponding change is made in TS25.212/222 to remedy this problem.

[0115] The constituent recursive convolutional encoders in the Turbo-coder as by TS25.212/222 have infinite impulse responses that are periodic with period 7 for positive time. The impact of certain patterns of surviving (i.e. non-punctured) bits in the parity bit stream can be qualitatively illustrated by considering how much information remains in these surviving parity bits.

[0116] The Turbo-coder produces 3 bit streams, systematic bits corresponding to the input sequence, parity bit stream 1 (output of 1st constituent encoder) and parity bit stream 2 (output of 2nd constituent encoder).

[0117] Note that the constituent recursive convolutional encoder is an LTI system on GF_2. Therefore, the output of the encoder is a sum of shifted versions of the impulse response of the encoder. Each shifted version of the impulse response corresponds to the locations of the 1's in the TB.

[0118] Certain puncturing patterns may result in a loss of distributed information about a small group of bits across the set of bits in one of the parity bit streams. For example, let the TB consist of 7 bits followed by many zeros. Now consider the problem of trying to determine the seven bits by observation of the output of one encoder after heavy puncturing. Each observation made at the output is a sum of a subset of the 7 bits. The subset for each particular observation is determined by the surviving bit period and the impulse response of the recursive encoding block.

[0119] For most puncture patterns, sums over 7 different subsets of the 7 bits can eventually be observed. Therefore, a system of 7 equations with 7 unknowns can be formed. Assuming that they are linearly independent, the values of the 7 bits may be determined.

[0120] However, when the periodicity of surviving bits is simple (one surviving parity bit per period) and the same as the period of the recursive encoding block, 7, then, due to the periodicity of the signal, every observation for $t > 6$ is the sum of the same subset of the 7 bits and so no new information is obtained by subsequent observations. Thus, a rank-1 system of equations is formed and a unique solution does not exist.

[0121] When the periodicity of surviving bits is not a multiple of 7, making observations of the parity bits will eventually form a rank-7 system of equations after several observations. For our 7-bit group, this is sufficient to uniquely determine the bits, i.e. information sufficient to determine the bits is distributed across the surviving parity bits.

[0122] It is also possible that some distributed information is lost even for non-simple periods, e.g., consider the case where the non-puncture pattern alternates between a simple period of three and four (two surviving parity bits per period with period = 7).

[0123] This results in a period 7 non-puncture pattern but with two surviving parity bits per period. The same argument above leads to a rank-2 system of seven equations. This is still insufficient to uniquely determine the group of bits, but does reduce the dimension of the space they may span. Clearly, some information about the TB may also be lost for non-simple surviving bit patterns.

[0124] At least two alternative approaches exist to avoid the problematic interactions between Turbo-coder output and puncturing in the rate-matching stages.

[0125] The avoidance of problematic puncturing patterns is an approach that requires the MAC-hs to avoid using puncturing patterns that lead to SNR degradation and does not use certain combinations for mapping incoming transport blocks sizes to HS-PDSCHs.

[0126] Avoidance would either require building lookup tables that identify the problematical configurations or evaluating the predicted degradation expression described previously in the MAC-hs scheduler.

[0127] An advantage of the look-up table approach is that no change in current standards would be required and that any particular implementation could be left vendor-specific.

[0128] A disadvantage of the avoidance approach is that it is complicated by the fact that there are several dimensions to the problem that will all play a role in determining if a particular configuration will give rise to degradation. Parameters the MAC-hs scheduler would need to take into account in addition include:

(1) transport block set size of HS-DSCH transmission;

(2) number of soft information bits to be stored at the WTRU for HARQ; and

(3) number of physical channel bits allocated for the HS-PDSCHs.

[0129] For FDD, these parameters are implied by the combination indicator for number of channelization codes and modulation format i ($1 < i < 29$), and the transport block size k_i, ($0 < k_i < 62$) in TS25.321.

[0130] Described below is one embodiment of the present invention that includes a combination of previously described techniques.

[0131] The hybrid ARQ functionality matches the number of bits at the output of the channel coder to the total number of bits of the HS-PDSCH set to which the HS-DSCH is mapped. The hybrid ARQ functionality is controlled by the redundancy version (RV) parameters. The exact set of bits at the output of the hybrid ARQ functionality depends on the number of input bits, the number of output bits, and the RV parameters.

[0132] The hybrid ARQ functionality consists of two rate-matching stages and a virtual buffer.

[0133] The first rate matching stage matches the number of input bits to the virtual IR buffer, information about which is provided by higher layers. Note that, if the number of input bits does not exceed the virtual IR buffering capability, the first rate-matching stage is transparent.

[0134] The second rate matching stage matches the number of bits after first rate matching stage to the number of physical channel bits available in the HS-PDSCH set in the TTI.

[0135] Definitions of notations used:

N^{TTI}: Number of bits in a transmission time interval before rate matching.

ΔN_i: An intermediate calculation variable.

$\Delta N_{i,l}^{TTI}$: If positive - number of bits to be repeated in each transmission time interval on TrCH i with transport format l.

If negative - number of bits to be punctured in each transmission time interval on TrCH i with transport format l.

ΔN_{PARITY} : Number of bits to adjust the length of parity streams by, in HARQ 1st stage rate-matching.

N_{data}: Total number of bits that are available for the HS-DSCH in a TTI.

e_{ini} Initial value of variable e in the rate matching pattern determination algorithm.

e_{plus} Increment of variable e in the rate matching pattern determination algorithm.

e_{minus} Decrement of variable e in the rate matching pattern determination algorithm.

b: Indicates systematic and parity bits

b=1: Systematic bit, x_k .

b=2: 1st parity bit (from the upper Turbo constituent encoder), z_k.

b=3: 2nd parity bit (from the lower Turbo constituent encoder), z'_k.

[0136] The HARQ bit separation function shall be performed in the same way as bit separation for turbo encoded TrCHs.

[0137] HARQ first stage rate matching for the HS-DSCH transport channel shall be performed using the method described below with the following specific parameters.

[0138] The maximum number of soft bits available in the virtual IR buffer is N_{IR} which is signaled from higher layers for each HARQ process. The number of coded bits in a TTI before rate matching is N^{TTI} this is deduced from information signaled from higher layers and parameters signaled on the High Speed Synchronization Control Channel (HS-SCCH) for each TTI. Note that HARQ processing and physical layer storage occurs independently for each HARQ process currently active.

[0139] If N_{IR} is greater than or equal to N^{TTI} (i.e. all coded bits of the corresponding TTI can be stored) the first rate matching stage shall be transparent. This can, for example, be achieved by setting $e_{minus} = 0$. Note that no repetition is performed.

[0140] If N_{IR} is smaller than N^{TTI} the parity bit streams are punctured by setting the rate matching parameter $\Delta N_{il}^{TTI} = N_{IR} - N^{TTI}$ where the subscripts i and l refer to transport channel and transport format in the referenced sub-clause. Note the negative value is expected when the rate matching implements puncturing. Bits selected for puncturing which appear as δ shall be discarded and not counted in the totals for the streams through the virtual IR buffer.

[0141] If first stage puncturing is to be performed, the procedure below shall be applied. Index b is used to indicate systematic (b=1), 1st parity (b=2), and 2nd parity bit (b=3). The parameter ΔN_{PARITY} :is the change in length to the parity streams to circumvent problematic puncturing rates.

The first stage rate matching delta is calculated as follows:

if puncturing is to be performed

$$X_i = \lfloor N^{TTI}/3 \rfloor; \quad PR = \frac{\lfloor -\Delta N_{il}^{TTI}/2 \rfloor}{X_i}; \quad \Delta N_{PARITY} = 0; \ \delta_{PR} = 49; \quad \alpha = 1$$

while $(\alpha \le 4)$

$$round = \frac{\left\lfloor 7 \cdot \alpha \cdot PR + \frac{1}{2} \right\rfloor}{7 \cdot \alpha}$$

$\lambda = PR - round$

$$\text{if}\left(|\lambda| > \frac{1}{\delta_{PR}}\right) or \left(PR > \frac{48}{49}\right) or \left(PR < \frac{1}{49}\right) \text{then}$$

$\alpha = \alpha + 1$

$\delta_{PR} = 98$

else if$(\lambda > 0)$ then

$$\Delta N_{PARITY} = \left\| \left\lfloor -\Delta N_{il}^{TTI} / 2 \right\rfloor - X_i \cdot \left(round - \frac{1}{\delta_{PR}} \right) \right\|$$

$\alpha = 5$

else

$$\Delta N_{PARITY} = \left\| \left\lfloor -\Delta N_{il}^{TTI} / 2 \right\rfloor - X_i \cdot \left(round + \frac{1}{\delta_{PR}} \right) \right\|$$

$\alpha = 5$

end if

end while

$$\Delta N_i = \begin{cases} \left\lfloor -\Delta N_{il}^{TTI} / 2 \right\rfloor - \Delta N_{PARITY}, b = 2 \\ \left\lceil -\Delta N_{il}^{TTI} / 2 \right\rceil + \Delta N_{PARITY}, b = 3 \end{cases}$$

a = 2 when b=2

a = 1 when b=3

[0142] If ΔN_i is calculated as 0 for b=2 or b=3, then the following procedure and the rate matching algorithm shall not be performed for the corresponding parity bit stream.

[0143] For each radio frame, the rate-matching pattern shall be calculated, where:

X_i is as above,

$e_{ini} = X_i$

$e_{plus} = a \times X_i$

$e_{minus} = a \times |\Delta N_i|$

[0144] HARQ second stage rate matching for the HS-DSCH transport channel shall be done using one of two possible methods.

[0145] If second stage puncturing is to be performed, and the Composite Puncturing Rate of one of the parity streams, calculated using the formula below falls in any of the intervals [91/128,92/128], [217/256, 222/256], [231/256, 232/256], [237/256, 238/256] or [487/512, 488/512], then puncturing of that parity stream shall be performed. Note, puncturing maybe carried out on one, both, or neither of the two parity streams, but never on the systematic parity stream.

[0146] Composite Puncturing Ratio, $CPR = \begin{cases} \dfrac{\lfloor N^{TTI}/3 \rfloor - N_{t,p1}}{N^{TTI}/3}, b = 2 \\ \dfrac{\lfloor N^{TTI}/3 \rfloor - N_{t,p2}}{N^{TTI}/3}, b = 3 \end{cases}$

[0147] Otherwise, second stage rate matching for the HS-DSCH transport channel shall be done with the following specific parameters. Bits selected for puncturing which appear as δ shall be discarded and are not counted in the streams towards the bit collection.

[0148] The parameters of the second rate matching stage depend on the value of the RV parameters s and r. The parameter s can take the value 0 or 1 to distinguish between transmissions that prioritize systematic bits (s = 1) and non systematic bits (s = 0). The parameter r (range 0 to r_{max}-1) changes the initial error variable e_{ini} in the case of puncturing. In case of repetition both parameters r and s change the initial error variable e_{ini}. The parameters X_i, e_{plus} and e_{minus} are calculated as per table 1 below.

[0149] Denote the number of bits before second rate matching as N_{sys} for the systematic bits, N_{p1} for the parity 1 bits, and N_{p2} for the parity 2 bits, respectively. Denote the number of physical channels used for the HS-DSCH by P. N_{data} is the number of bits available to the HS-DSCH in one TTI and defined as $N_{data}=P\times 3\times N_{data1}$. The rate matching parameters are determined as follows.

[0150] For $N_{data} \le N_{sys} + N_{p1} + N_{p2}$, puncturing is performed in the second rate matching stage. The number of transmitted systematic bits in a transmission is $N_{t,sys} = \min\{N_{sys}, N_{data}\}$ for a transmission that prioritizes systematic bits and $N_{t,sys} = \max\{N_{data} - (N_{p1} + N_{p2}), 0\}$ for a transmission that prioritizes non systematic bits.

[0151] For $N_{data} > N_{sys} + N_{p1} + N_{p2}$ repetition is performed in the second rate matching stage. A similar repetition rate in all bit streams is achieved by setting the number of transmitted systematic bits to $N_{t,sys} = \left\lfloor N_{sys} \cdot \frac{N_{data}}{N_{sys} + 2N_{p1}} \right\rfloor$.

[0152] The number of parity bits in a transmission is: $N_{t,p1} = \max\left(\left\lfloor \frac{N_{data} - N_{t,sys}}{2} \right\rfloor - \Delta N_{PARITY}, 0\right)$ and $N_{t,p2} = N_{data} - (N_{t,sys} + N_{t,p1})$ for the parity 1 and parity 2 bits, respectively.

	X_i	e_{plus}	e_{minus}
Systematic RM S	N_{sys}	N_{sys}	$\lvert N_{sys} - N_{t,sys} \rvert$
Parity 1 RM P1_2	N_{p1}	$2 \cdot N_{p1}$	$2 \cdot \lvert N_{p1} - N_{t,p1} \rvert$
Parity 2 RM P2_2	N_{p2}	N_{p2}	$\lvert N_{p2} - N_{t,p2} \rvert$

Table 1: Parameters for HARQ second rate matching

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[0153] Table 1 above summarizes the resulting parameter choice for the second rate matching stage. The rate matching parameter e_{ini} is calculated for each bit stream according to the RV parameters r and s using

$e_{ini}(r) = \{(X_i - \lfloor r \cdot e_{plus} / r_{\max} \rfloor - 1) \bmod e_{plus}\} + 1$ in the case of puncturing ,

i.e., $N_{data} \le N_{sys} + N_{p1} + N_{p2}$, and

$e_{ini}(r) = \{(X_i - \lfloor (s + 2 \cdot r) \cdot e_{plus} / (2 \cdot r_{\max}) \rfloor - 1) \bmod e_{plus}\} + 1$ for repetition, i.e., $N_{data} > N_{sys} + N_{p1} + N_{p2}$. Where $r \in \{0,1,\cdots,r_{\max} - 1\}$ and $r_{\max}$ is the total number of redundancy versions allowed by varying r. Note that r_{max} varies depending on the modulation mode, i.e. for 16QAM $r_{max} = 2$ and for QPSK $r_{max} = 4$.

[0154] Note: For the modulo operation the following clarification is used: the value of (x mod y) is strictly in the range of 0 to y-1 (i.e. -1 mod 10 = 9).

[0155] HARQ second stage rate matching for the HS-DSCH transport channel shall be done with the method described below, which separates each stream into segments with specific parameters calculated below. Bits selected for puncturing which appear as δ shall be discarded and are not counted in the streams towards the bit collection.

[0156] The parity stream will be segmented into 3 segments, the first segment will be made up of the first X_{seg1} bits of the parity stream, the second segment will be made up of the next X_{seg2} bits, and the last segment will be made up of the remaining X_{seg3} bits.

[0157] The first segment is denoted by $x_{i,1}, x_{i,2}, \ldots x_{i,Xseg1}$

The second segment by $x_{i,Xseg1+1}, x_{i,Xseg1+2}, \ldots x_{i,Xseg2}$;

And the final segment by $x_{i,Xseg1+Xseg2+1}, x_{i,Xseg1+Xseg2+2}, \ldots x_{i,X_i}$

Where $X_{seg1} = 42 \cdot \lfloor X_i / 98 \rfloor$, $X_{seg2} = 56 \cdot \lfloor X_i / 98 \rfloor$, $X_{seg3} = X_i \bmod 98$

[0158] Note: If X_i is less than 98 only the third segment exists, and if X_i is a multiple of 98 then the third segment will be empty. For the case where a particular

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segment is empty, then of course no puncturing is performed on that non-existent segment.

[0159] Additional parameters for HARQ Second Rate Matching Stage for problematic puncturing rates

[0160] Parameters P, N_{data}, N_{sys}, N_{p1}, N_{p2}, $N_{p,t1}$, and $N_{p,t2}$ are calculated, additional parameters are defined below.

[0161] Denote the number of parity 1 bits before second rate matching after segmentation as $N_{p1,seg1}$, $N_{p1,seg2}$, $N_{p1,seg3}$ for the parity 1 bits in the 1st, 2nd and 3rd segment respectively. Denote the number of parity 2 bits before second rate matching after segmentation as $N_{p2,seg1}$, $N_{p2,seg2}$, $N_{p2,seg3}$ for the parity 1 bits in the 1st, 2nd and 3rd segment respectively. The rate matching parameters are determined as follows.

[0162] For $N_{data} \le N_{sys} + N_{p1} + N_{p2}$, puncturing is performed in the second rate matching stage.

[0163] The number of parity bits after segmentation is

$$N_{pb,seg1} = 42 \cdot \lfloor N_{pb}/98 \rfloor$$
$$N_{pb,seg2} = 56 \cdot \lfloor N_{pb}/98 \rfloor$$
$$N_{pb,seg3} = N_{pb} \bmod 98$$

[0164] The number of parity bits in each segment for parity 1 bits (b=2), and parity 2bits (b=3) is:

$$N_{t,pb,seg1} = \left\lfloor \frac{49 \cdot N_{t,pb} \cdot \lfloor N_{pb}/98 \rfloor}{N_{pb}} + \frac{1}{2} \right\rfloor;$$
$$N_{t,pb,seg2} = \left\lfloor \frac{49 \cdot N_{t,pb} \cdot \lfloor N_{pb}/98 \rfloor}{N_{pb}} + \frac{1}{2} \right\rfloor;$$
$$N_{t,pb,seg3} = N_{t,pb} - \left(N_{t,pb,seg1} + N_{t,pb,seg2}\right)$$

[0165] The parameters X_i, e_{plus} and e_{minus} are calculated as per table 2 below.

Stream	*Segment*	X_i	e_{plus}	e_{minus}
Systematic RM S		N_{sys}	N_{sys}	$\lvert N_{sys} - N_{t,sys} \rvert$
Parity 1 RM P1_2	1st	$N_{p1,seg1}$	$2 \cdot N_{p1,seg1}$	$2 \cdot \lvert N_{p1,seg1} - N_{t,p1,seg1} \rvert$
	2nd	$N_{p1,seg2}$	$2 \cdot N_{p1,seg2}$	$2 \cdot \lvert N_{p1,seg2} - N_{t,p1,seg2} \rvert$
	3rd	$N_{p1,seg3}$	$2 \cdot N_{p1,seg3}$	$2 \cdot \lvert N_{p1,seg3} - N_{t,p1,seg3} \rvert$
Parity 2 RM P2_2	1st	$N_{p2,seg1}$	$N_{p2,seg1}$	$\lvert N_{p2,seg1} - N_{t,p2,seg1} \rvert$
	2nd	$N_{p2,seg2}$	$N_{p2,seg2}$	$\lvert N_{p2,seg2} - N_{t,p2,seg2} \rvert$
	3rd	$N_{p2,seg3}$	$N_{p2,seg3}$	$\lvert N_{p2,seg3} - N_{t,p2,seg3} \rvert$

Table 2: Parameters for dithered HARQ second rate matching

[0166] The rate matching parameter e_{ini} is calculated for each segment of bit stream according to the RV parameters r and s using $e_{ini}(r) = \{(X_i - \lfloor r \cdot e_{plus} / r_{\max} \rfloor - 1) \bmod e_{plus}\} + 1$ in the case of puncturing. Where $r \in \{0,1,\cdots,r_{\max} - 1\}$ and $r_{\max}$ is the total number of redundancy versions allowed by varying r. Note that r_{max} varies depending on the modulation mode, i.e. for 16QAM $r_{max} = 2$ and for QPSK $r_{max} = 4$.

[0167] Note: For the modulo operation the following clarification is used: the value of (x mod y) is strictly in the range of 0 to y-1 (i.e. -1 mod 10 = 9). The rate matching algorithm is called for each segment of the parity stream in turn.

[0168] For both parity streams, after the rate matching algorithm has been called for each of the three segments, the three punctured segments should be concatenated together in their original order.

[0169] The re-concatenated bit stream is denoted by: $x_{o,seg1,1}, x_{o,seg1,2}, \ldots x_{o,seg1,N_{t,p1,seg1}}, x_{o,seg2,1}, x_{o,seg2,2}, \ldots x_{o,seg2,N_{t,p1,seg2}}, x_{o,seg3,1}, x_{o,seg3,2}, \ldots x_{o,seg3,N_{t,p1,seg3}}$

[0170] The HARQ bit collection is achieved using a rectangular interleaver of size $N_{row} \times N_{col}$. The number of rows and columns are determined from:

$$N_{row} = 4 \text{ for 16QAM and } N_{row} = 2 \text{ for QPSK}$$

$$N_{col} = N_{data} / N_{row}$$

where N_{data} is used.

[0171] Data is written into the interleaver column by column, and read out of the interleaver column by column starting from the first column.

[0172] $N_{t,sys}$ is the number of transmitted systematic bits. Intermediate values N_r and N_c are calculated using:

$$N_r = \left\lfloor \frac{N_{t,sys}}{N_{col}} \right\rfloor \text{ and } N_c = N_{t,sys} - N_r \cdot N_{col}.$$

[0173] If N_c=0 and $N_r > 0$, the systematic bits are written into rows 1...N_r.

[0174] Otherwise systematic bits are written into rows 1...N_r+1 in the first N_c columns and, if $N_r > 0$, also into rows 1...N_r in the remaining N_{col}-N_c columns.

[0175] The remaining space is filled with parity bits. The parity bits are written column wise into the remaining rows of the respective columns. Parity 1 and 2 bits are written in alternating order, starting with a parity 2 bit in the first available column with the lowest index number. If the two parity streams are of unequal length, Parity 1 and 2 bits shall be written alternately, again starting with a parity 2 bit, until the end of the shorter parity stream, then the remaining parity bits from the longer stream shall be written.

[0176] In the case of 16QAM for each column the bits are read out of the interleaver in the order row 1, row 2, row 3, row 4. In the case of QPSK for each column the bits are read out of the interleaver in the order row1, row2.

[0177] When the analysis of the rate matching issue was restricted to the situation in which the first stage HS-DSCH rate matching is transparent it was shown

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that the performance degradation arises from an interaction between the periodicity of the rate matching pattern and the inherent periodicity of the turbo encoder. In particular, it was shown that at the problematic code rates, the positions (in the unpunctured bit stream) of survivor (i.e. non punctured) bits lie in the same position or positions within a modulo 7 period for long segments of the unpunctured stream. It has been demonstrated that performance degradations arise via exactly the same mechanism when the first stage is not transparent.

[0178] In the following description, a "puncturing pattern" is defined to be the pattern of positions of bits that are punctured from an original stream. "Puncturing Rate" is defined to be the reciprocal of the number of bits between punctured bit positions (inclusive of the punctured positions) in the original bit stream.

[0179] In the case of two-stage rate matching, puncturing that leads to degradation may occur in two ways:

1) A pattern arising from bits punctured in the first stage only

2) A pattern arising from bits punctured after the second stage; this pattern is dependent upon both the first and second rate matching stages.

[0180] In order to avoid either of these puncturing mechanisms that cause a performance degradation, the following methodology has been adopted:

[0181] In the first stage, test whether the puncturing will cause a problematic puncturing pattern. This is achieved by evaluating an "implicit duration" function, which predicts the length of periodicity in the puncturing pattern. The first stage rate matching is only adjusted if the calculated implicit duration indicates a necessity. In this case, the amount of bits punctured in the first parity stream is increased slightly, whilst in the second stream the number is correspondingly decreased slightly. This has the effect of shifting the puncturing rates in both streams to break up modulo 7 periodicity, whilst keeping the total amount of punctured bits the same. The adjustment in the puncturing rate in each of the streams is kept sufficiently small to leave the coding performance in each stream unaffected.

[0182] In the second stage, a composite puncturing rate for each stream, taking into account adjustments to the puncturing rate carried out at the first stage is calculated. The composite puncturing rate in each stream is compared with a look up table, which predicts rates at which modulo-7 periodic patterns, and hence coding degradations will arise. If the composite rate of a stream falls within a range of problematic rates, a "dithering" algorithm is applied.

[0183] Differing puncturing rates are applied in the two parity streams if the puncturing pattern in the first stage will lead to a performance degradation, or is likely to contribute to an unwanted pattern after second stage rate matching. In this case, the number of bits punctured in the first parity stream is reduced by an amount ΔN_{PARITY}, whilst the number of bits punctured in the second stream is increased by the same amount. The decision as to whether such a change should take place is based upon a calculated parameter, which estimates the inverse of the length of runs of survivor bits which hold the same modulo 7 position in the unpunctured stream. This length becomes greater than 49 bits (i.e. 7 modulo 7 periods), then the adjustment to the lengths of the streams is applied.

[0184] The dithered puncturing algorithm may be applied to either or both of the two parity streams in the second stage. When processing a parity stream, the algorithm employs two puncturing rates, one higher than the original, and one lower, it then switches between these two puncturing rates whilst applying puncturing to the parity bit stream. The total number of bits punctured is kept the same as it would have been with the original algorithm. Generically it is possible to have one or many switching points between the two puncturing rates within a parity stream. The number of points is not critical to the performance, since the fraction of the bit stream punctured at each rate is independent of the number of switching points.

[0185] The number of switching points is set to one (or two), meaning that the punctured stream consists of two (or three) segments in which the first segment uses a lower puncturing rate than the original, the second uses a higher puncturing rate. If the two segments do not account for the whole of the parity stream, a third segment is

allowed at the end that is punctured at the original rate. The third segment is kept short, and allows for puncturing exactly the correct amount of bits to maintain the overall puncturing rate. By breaking the parity stream into a low number of segments in this way, the original rate matching algorithm can easily be used with some minor parameter changes.

[0186] The difference between the higher puncturing rate in the first segment and the original rate, and also between the lower puncturing rate in the second segment and the original has been set to 1/49. This selection allows for problematic rates to be avoided in all cases whilst not representing a significant change in coding rate.

[0187] In the majority of cases, the modified rate matching algorithm operates in exactly the same manner as previously defined. In the minority of cases in which either the first or second stage rate matching would lead to a performance degradation, unequal length streams and/or dithering are applied. Both of these modifications do not change the body of the rate matching procedure in any way, but rather the rate matching parameters that are applied. Furthermore, in an implementation, the modifications can be achieved with a modification to the Rate Matching DSP software without affecting any other part of the system.

[0188] The foregoing is a description of a preferred embodiment and alternative solutions to providing detecting, avoiding/correcting problematic Turbo code puncturing patterns. While this invention has been particularly shown and described with reference to preferred embodiments, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention as described hereinabove.

* * *

CLAIMS

What is claimed is:

1. A method of avoiding problematic Turbo code puncturing patterns due to interactions that occur between the output of a Turbo coder output and rate matching stages used to perform puncturing, the method comprising:

(a) creating high-rate Turbo codes by puncturing parity bits of a lower-rate code until a desired code rate is attained;

(b) interleaving the parity bits before rate matching occurs; and

(c) subsequently de-interleaving the parity bits to avoid a need to periodically sample the parity bits when performing periodic sampling in rate matching, thereby mitigating the effect of the periodicity of the puncturing pattern.

2. The method of claim 1 wherein the method is implemented by a wireless transmit/receive unit (WTRU).

3. A wireless transmit/receive unit (WTRU) comprising:

(a) a Turbo-coder configured to generate a first parity bit stream and a second parity bit stream;

(b) a first time-varying interleaver inserted into the first parity bit stream to interleave parity bits in the first parity bit stream;

(c) a second time-varying interleaver inserted into the second parity bit stream to interleave parity bits in the second parity bit stream; and

(d) at least one rate matching stage that receives the interleaved parity bits, wherein the parity bits are subsequently de-interleaved to avoid a need to periodically sample the parity bits when performing periodic sampling in rate matching, thereby mitigating the effect of the periodicity of the puncturing pattern.

4. A Turbo coding method comprising:

(a) employing a plurality of rate matching stages for processing a plurality of individual parity bit streams derived through puncturing a selected number of bits, wherein degradations in the quality of punctured error correction coded transmissions having a first group of parity 1 (P1) bits and a second group of parity 2 (P2) bits are identified;

(b) biasing the puncturing rates of the P1 and P2 bits by adding a number of non-punctured P1 bits to the first group and decreasing the number of non-punctured P2 bits in the second group by the number of non-punctured P1 bits added to the first group;

(c) determining a number of bits $\hat{N}$ using $\hat{N} = \left\lfloor \frac{4I}{7P} + \frac{1}{2} \right\rfloor$ wherein I is the number of bits at the input to each branch of rate matching and P is the total number of the P1 and P2 bits at the output of rate matching; and

(d) if $\left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right| < 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor$, calculating the bias

$$\Delta = \left\lceil \max\left\{ \frac{I}{\left\lfloor \frac{7\hat{N}-1}{2} \right\rfloor} - \frac{P}{2}, \frac{P}{2} - \frac{I}{\left\lceil \frac{7\hat{N}+1}{2} \right\rceil} \right\} \right\rceil ; \text{ and}$$

(e) setting $\Delta = 0$ if $\left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right|$ *is not* $< 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor$.

5. The method of claim 4 wherein non-puncturing patterns with a period of $7\hat{N}/2$ cause degradation in performance results and $\hat{N}$ is a whole number.

6. The method of claim 5 wherein the non-puncturing patterns will be employed whenever the average non-puncturing period of P1 or P2 bits is within ±1 or ±½ of $7\hat{N}/2$ for even and odd $\hat{N}$ respectively.

7. A wireless transmit/receive unit (WTRU) comprising:

(a) a plurality of rate matching stages for processing a plurality of individual parity bit streams derived through puncturing a selected number of bits, wherein degradations in the quality of punctured error correction coded transmissions having a first group of parity 1 (P1) bits and a second group of parity 2 (P2) bits are identified, and the puncturing rates of the P1 and P2 bits are biased by adding a number of non-punctured P1 bits to the first group and decreasing the number of non-punctured P2 bits in the second group by the number of non-punctured P1 bits added to the first group; and

(b) a processor configured to determine a number of bits $\hat{N}$ using $\hat{N} = \left\lfloor \frac{4I}{7P} + \frac{1}{2} \right\rfloor$ wherein I is the number of bits at the input to each branch of rate matching and P is the total number of the P1 and P2 bits at the output of rate matching;

(c) the processor configured to calculate the bias

$$\Delta = \left\lceil \max\left\{ \frac{I}{\left\lfloor \frac{7\hat{N}-1}{2} \right\rfloor} - \frac{P}{2}, \frac{P}{2} - \frac{I}{\left\lceil \frac{7\hat{N}+1}{2} \right\rceil} \right\} \right\rceil \text{ if } \left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right| < 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor \text{; and}$$

(d) the processor configured to set $\Delta = 0$ if $\left| \frac{I}{(P/2)} - \frac{7\hat{N}}{2} \right|$ *is not* $< 1 - \frac{\hat{N}}{2} + \left\lfloor \frac{\hat{N}}{2} \right\rfloor$.

8. The WTRU of claim 7 wherein non-puncturing patterns with a period of $7\hat{N}/2$ cause degradation in performance results and $\hat{N}$ is a whole number.

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9. The WTRU of claim 8 wherein the non-puncturing patterns will be employed whenever the average non-puncturing period of P1 or P2 bits is within ±1 or ±½ of $7\hat{N}/2$ for even and odd $\hat{N}$ respectively.

ABSTRACT

Detecting, avoiding and/or correcting problematic puncturing patterns in parity bit streams used when implementing punctured Turbo codes is achieved without having to avoid desirable code rates. This enables identification/avoidance of regions of relatively poor Turbo code performance. Forward error correction comprising Turbo coding and puncturing achieves a smooth functional relationship between any measure of performance and the effective coding rate resulting from combining the lower rate code generated by the Turbo encoder with puncturing of the parity bits. In one embodiment, methods to correct/avoid degradations due to Turbo coding are implemented by puncturing interactions when two or more stages of rate matching are employed.

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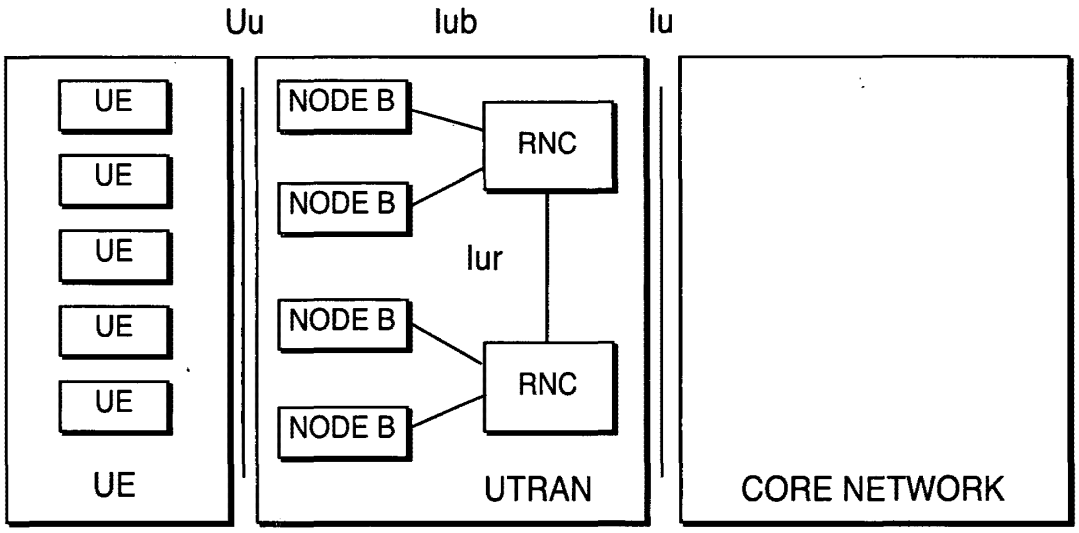


FIG. 1
PRIOR ART

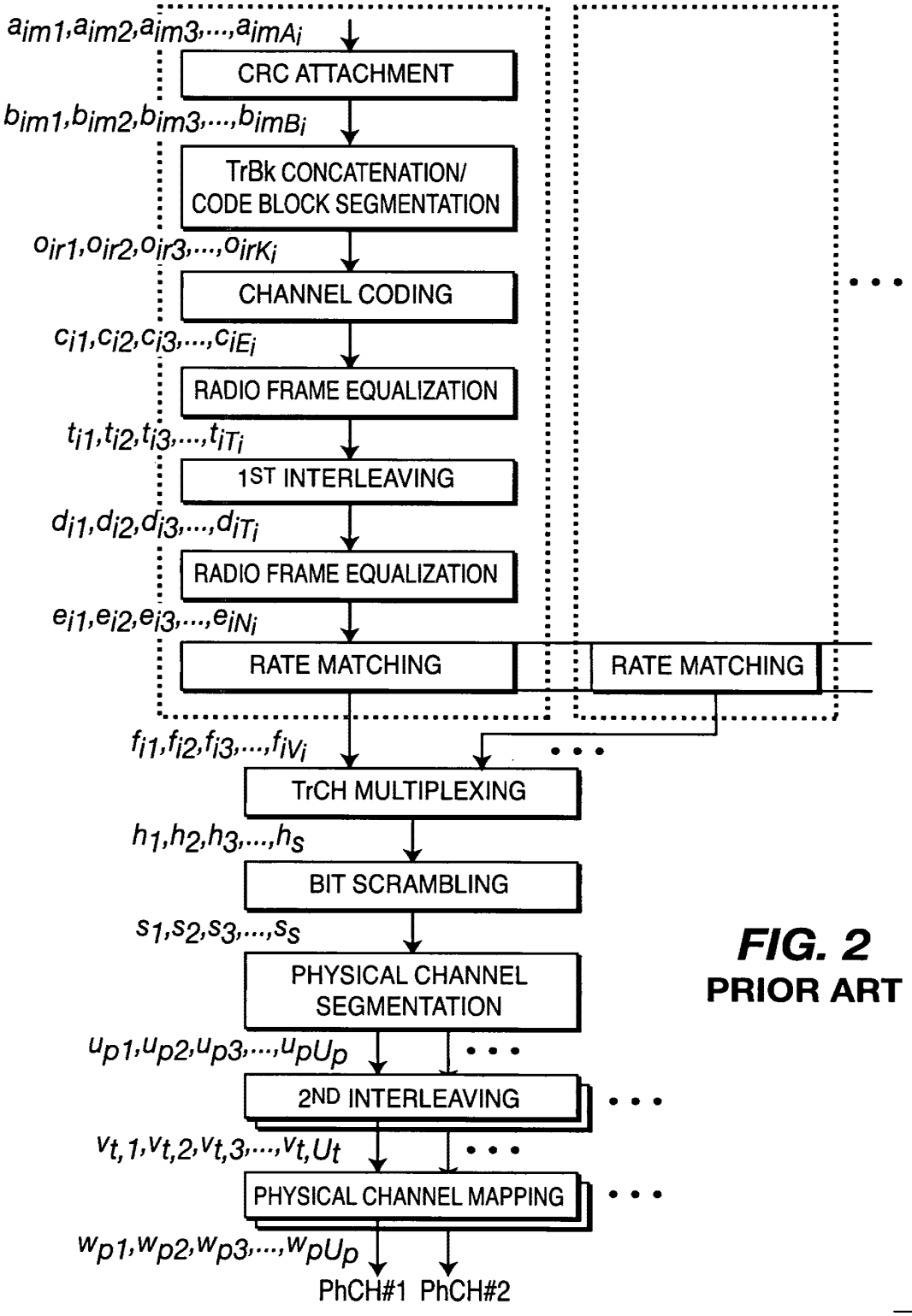


FIG. 2
PRIOR ART

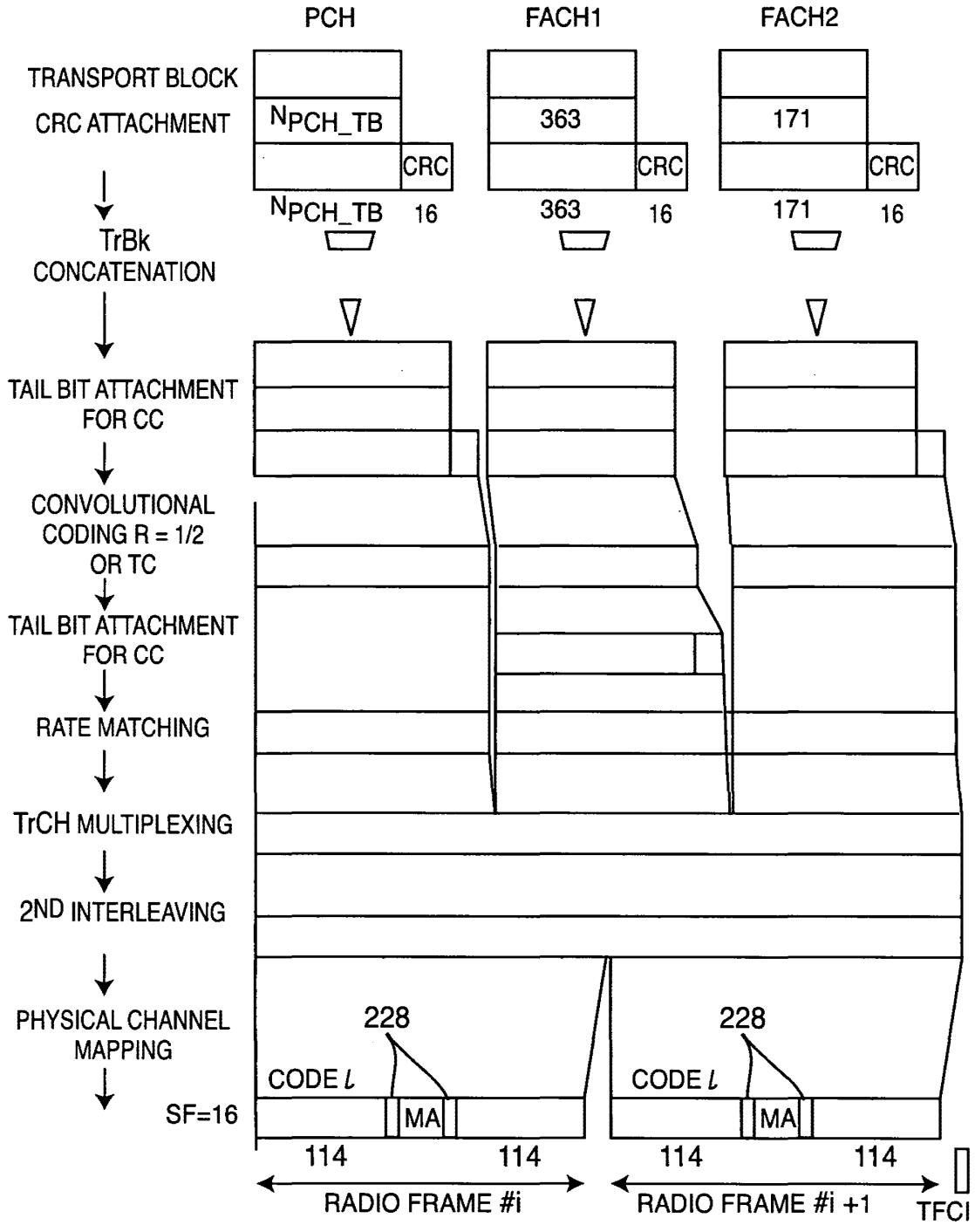


FIG. 3
PRIOR ART

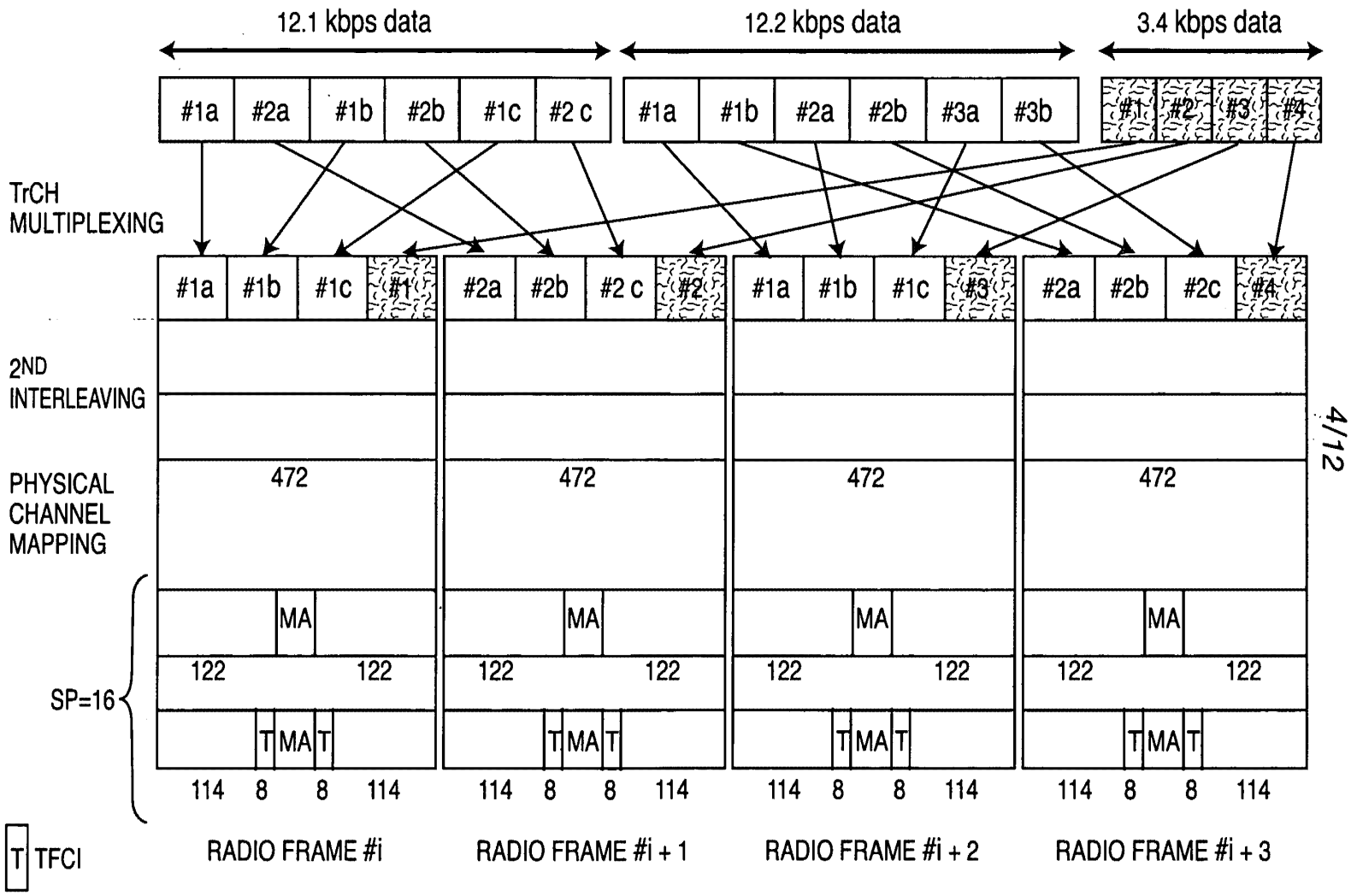


FIG. 4 **PRIOR ART**

4/12

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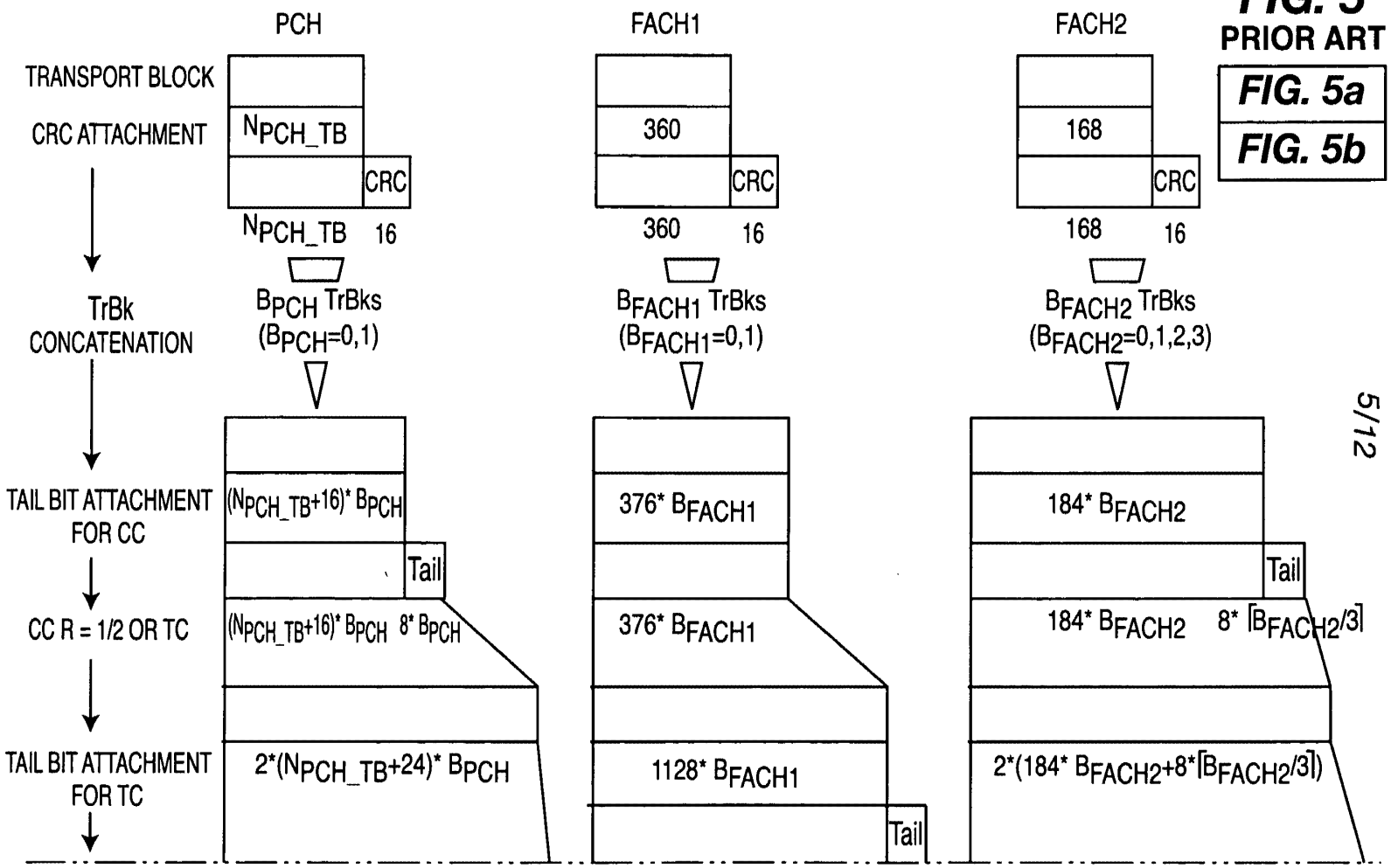


FIG. 5
PRIOR ART

FIG. 5a
FIG. 5b

FIG. 5a

5/12

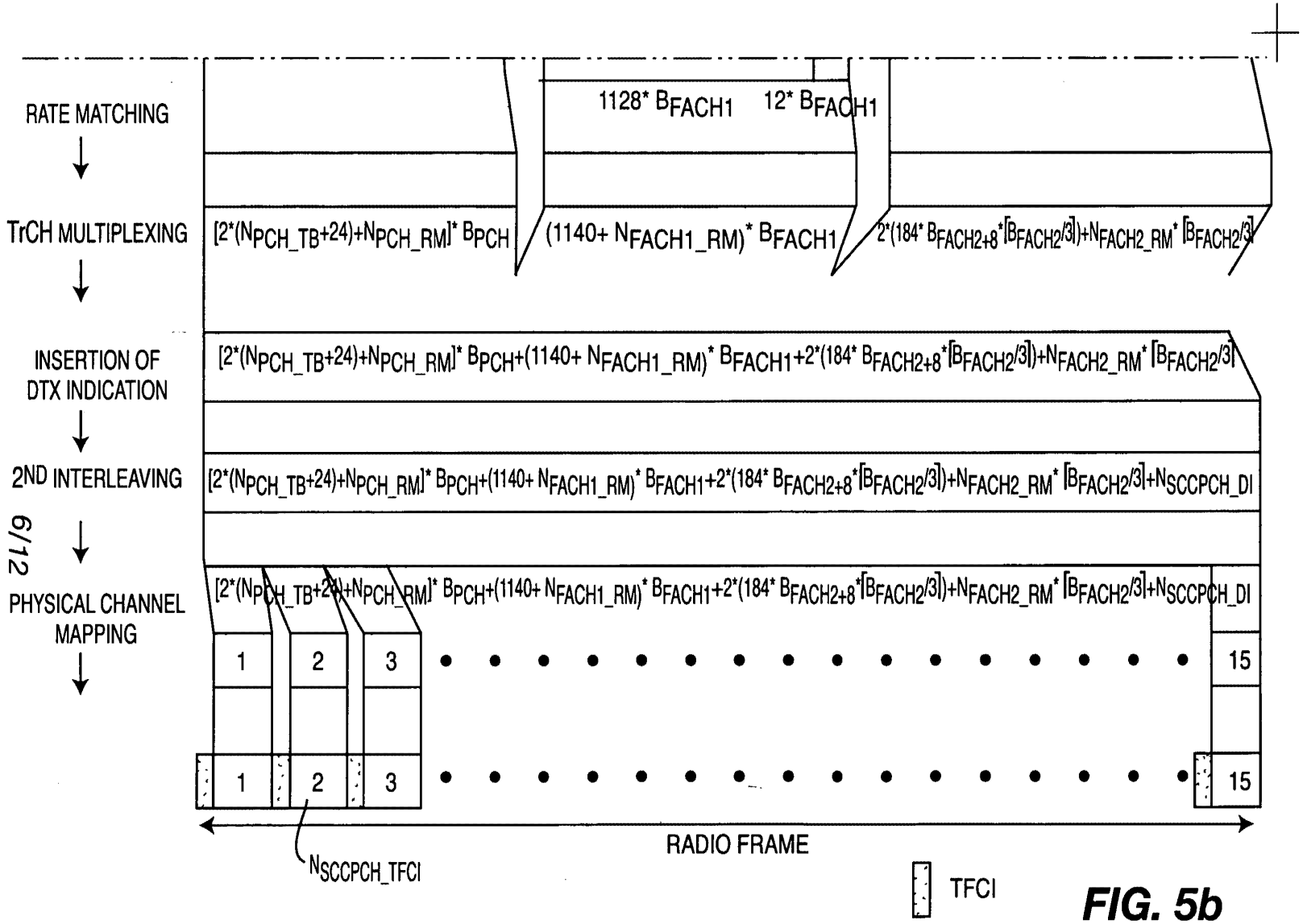

RATE MATCHING
TrCH MULTIPLEXING
INSERTION OF DTX INDICATION
2ND INTERLEAVING
6/12
PHYSICAL CHANNEL MAPPING
1128* BFACH1
12* BFACH1
[2*(NPCH_TB+24)+NPCH_RM]* BPCH
(1140+ NFACH1_RM)* BFACH1
2*(184* BFACH2+8*⌈BFACH2/3⌉)+NFACH2_RM* ⌈BFACH2/3⌉
[2*(NPCH_TB+24)+NPCH_RM]* BPCH+(1140+ NFACH1_RM)* BFACH1+2*(184* BFACH2+8*⌈BFACH2/3⌉)+NFACH2_RM* ⌈BFACH2/3⌉
[2*(NPCH_TB+24)+NPCH_RM]* BPCH+(1140+ NFACH1_RM)* BFACH1+2*(184* BFACH2+8*⌈BFACH2/3⌉)+NFACH2_RM* ⌈BFACH2/3⌉+NSCCPCH_DI
1
2
3
15
RADIO FRAME
NSCCPCH_TFCI
TFCI

FIG. 5b

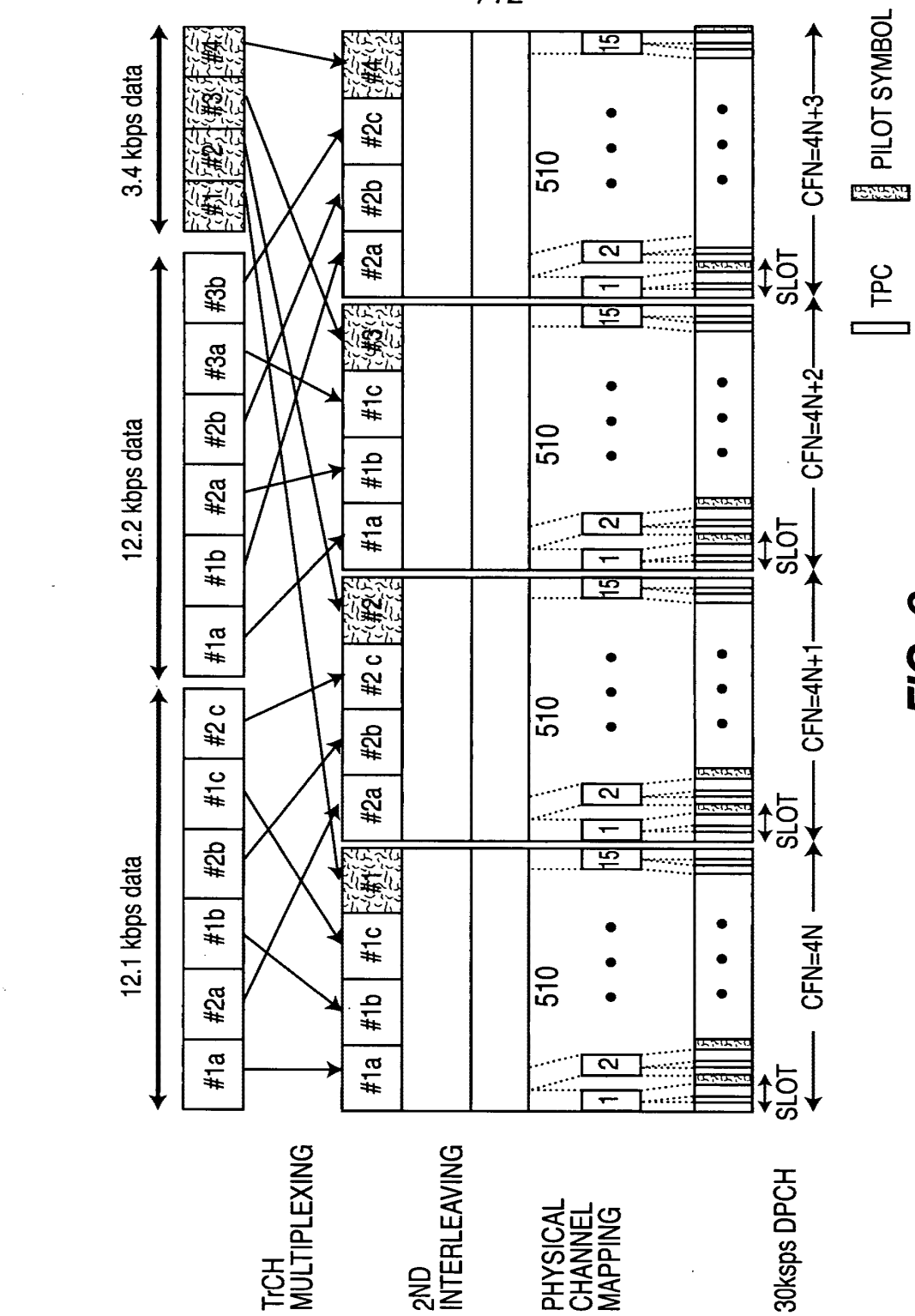


FIG. 6
PRIOR ART

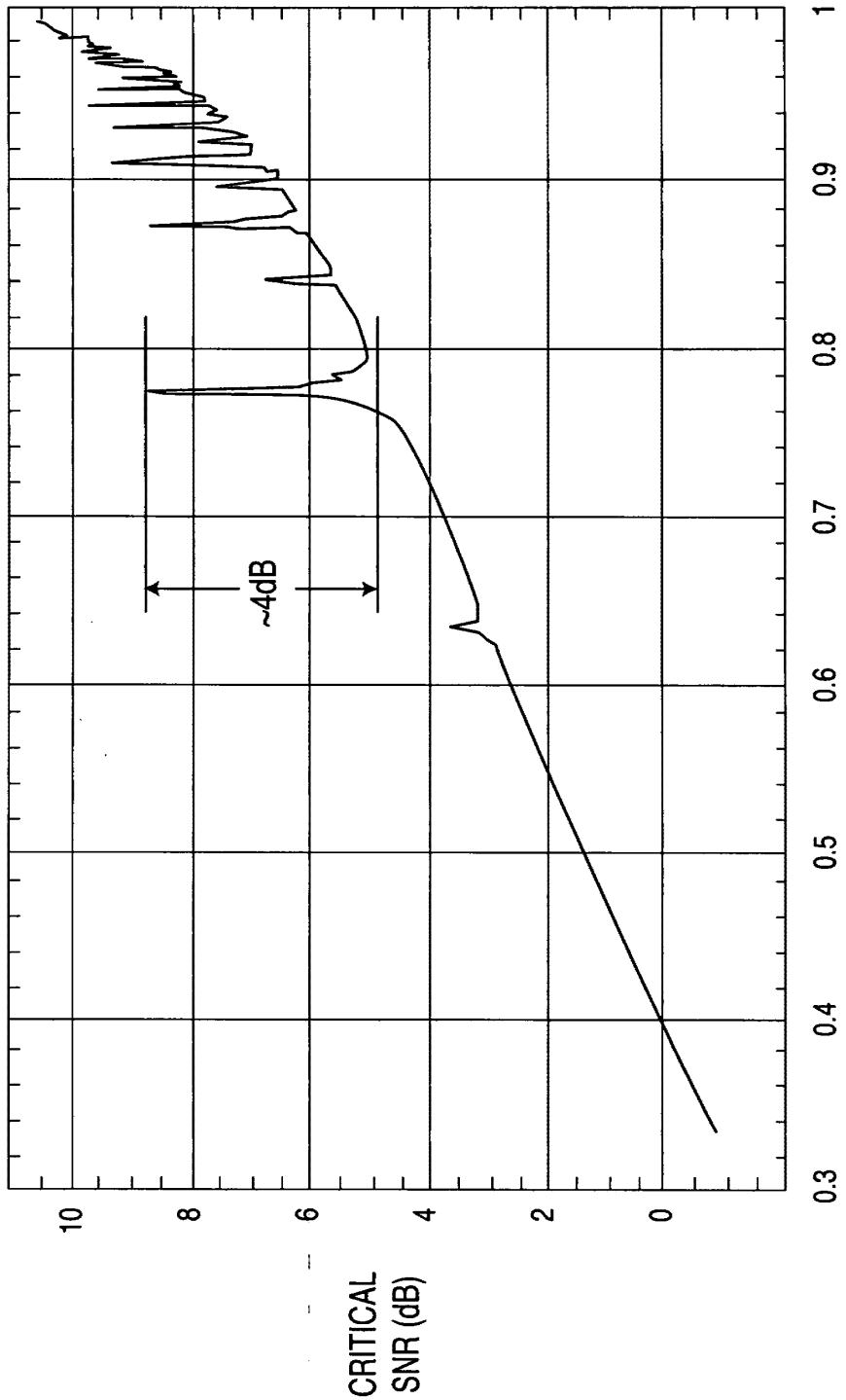


FIG. 7
PRIOR ART

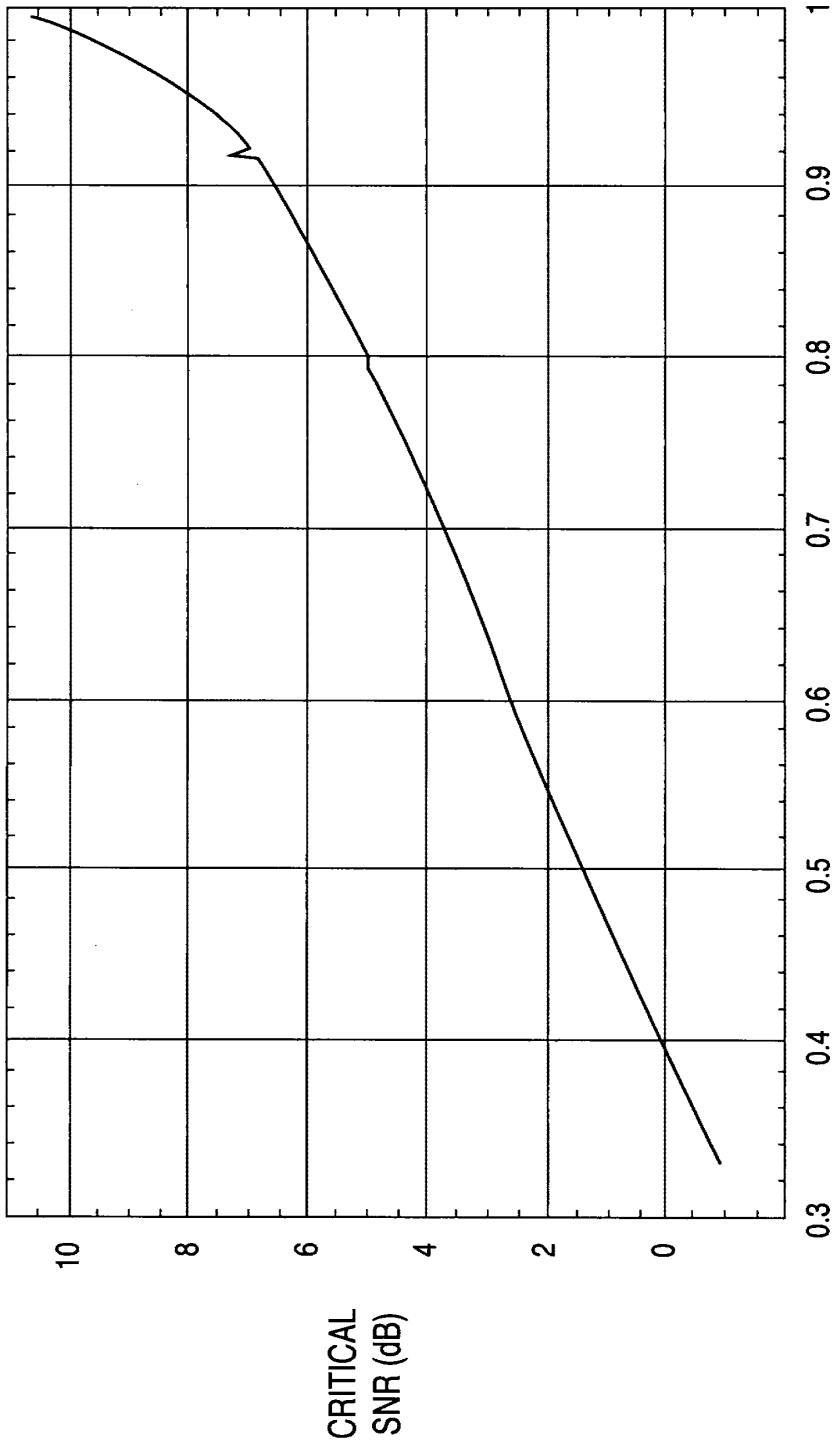


FIG. 8

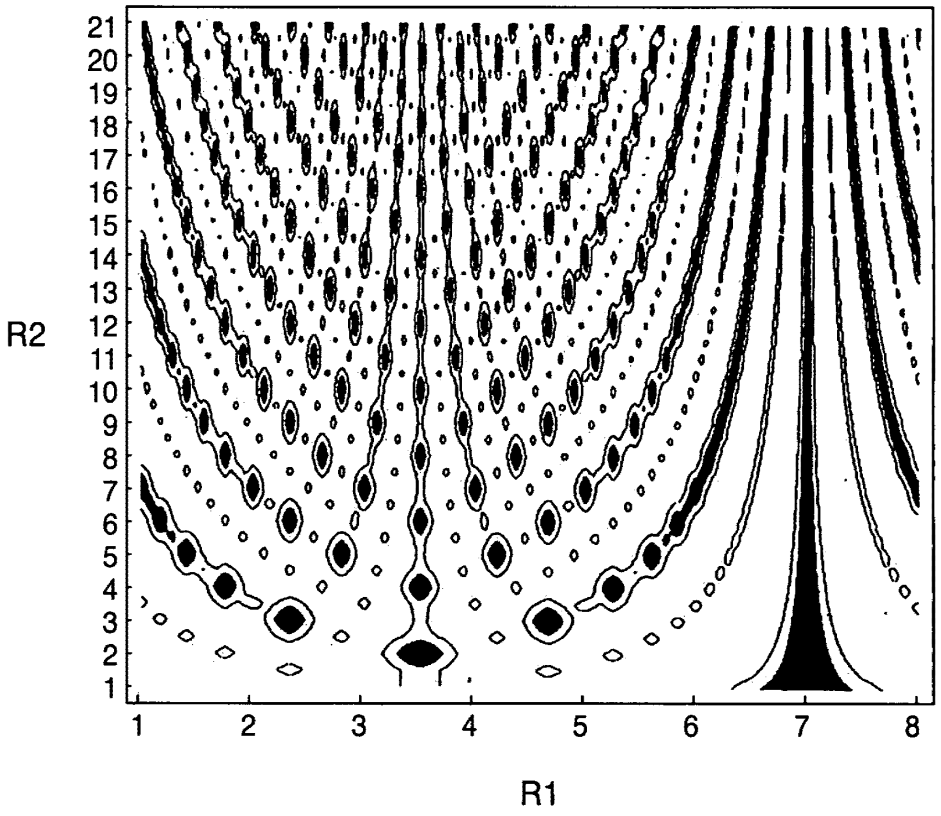


FIG. 9

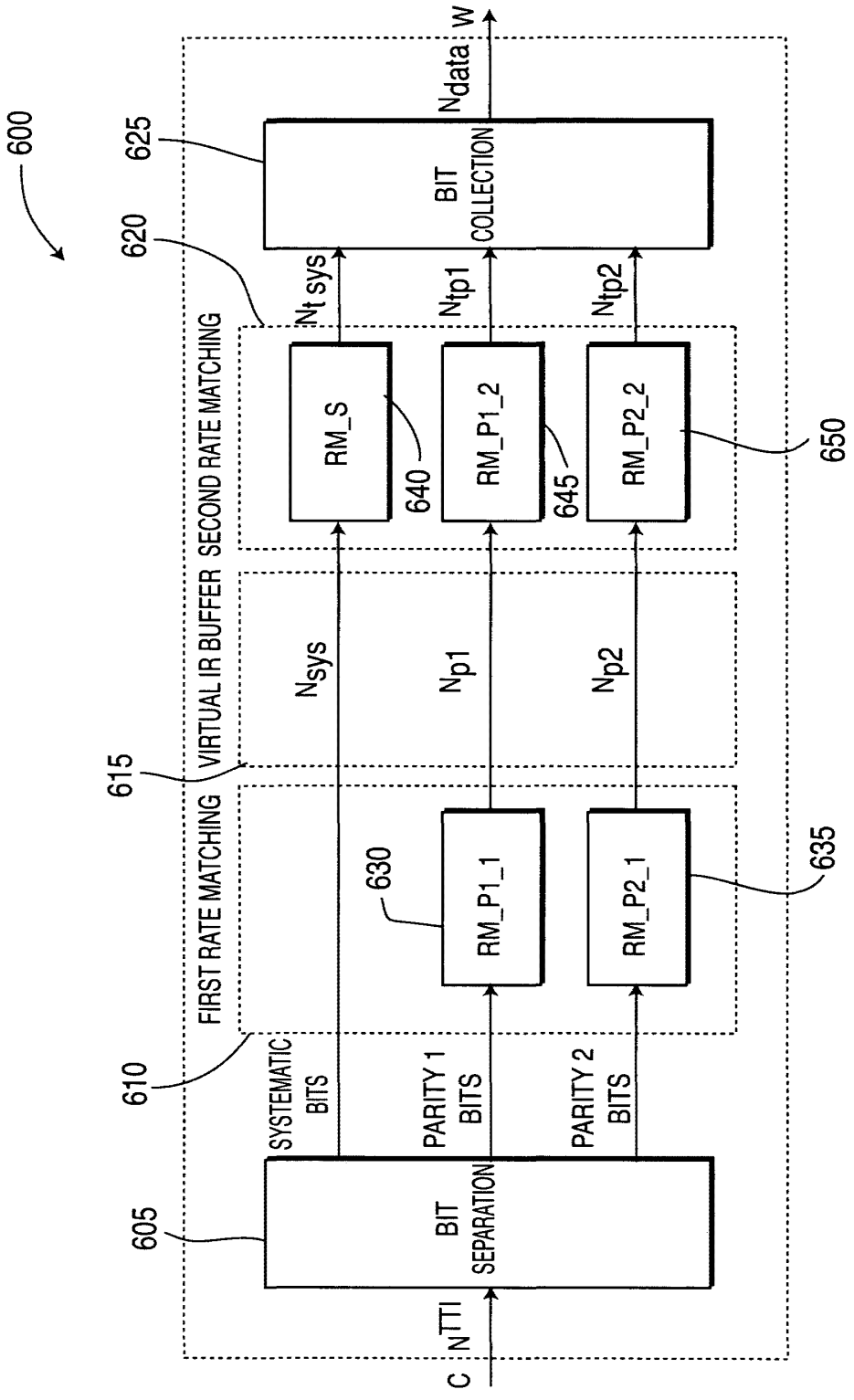

600
625
620
615
610
605
630
640
645
650
635
C
N^{TTI}
BIT SEPARATION
SYSTEMATIC BITS
PARITY 1 BITS
PARITY 2 BITS
FIRST RATE MATCHING
VIRTUAL IR BUFFER
SECOND RATE MATCHING
RM_P1_1
RM_P2_1
RM_S
RM_P1_2
RM_P2_2
N_{sys}
N_{p1}
N_{p2}
$N_{t\,sys}$
N_{tp1}
N_{tp2}
BIT COLLECTION
N_{data}
W

FIG. 10

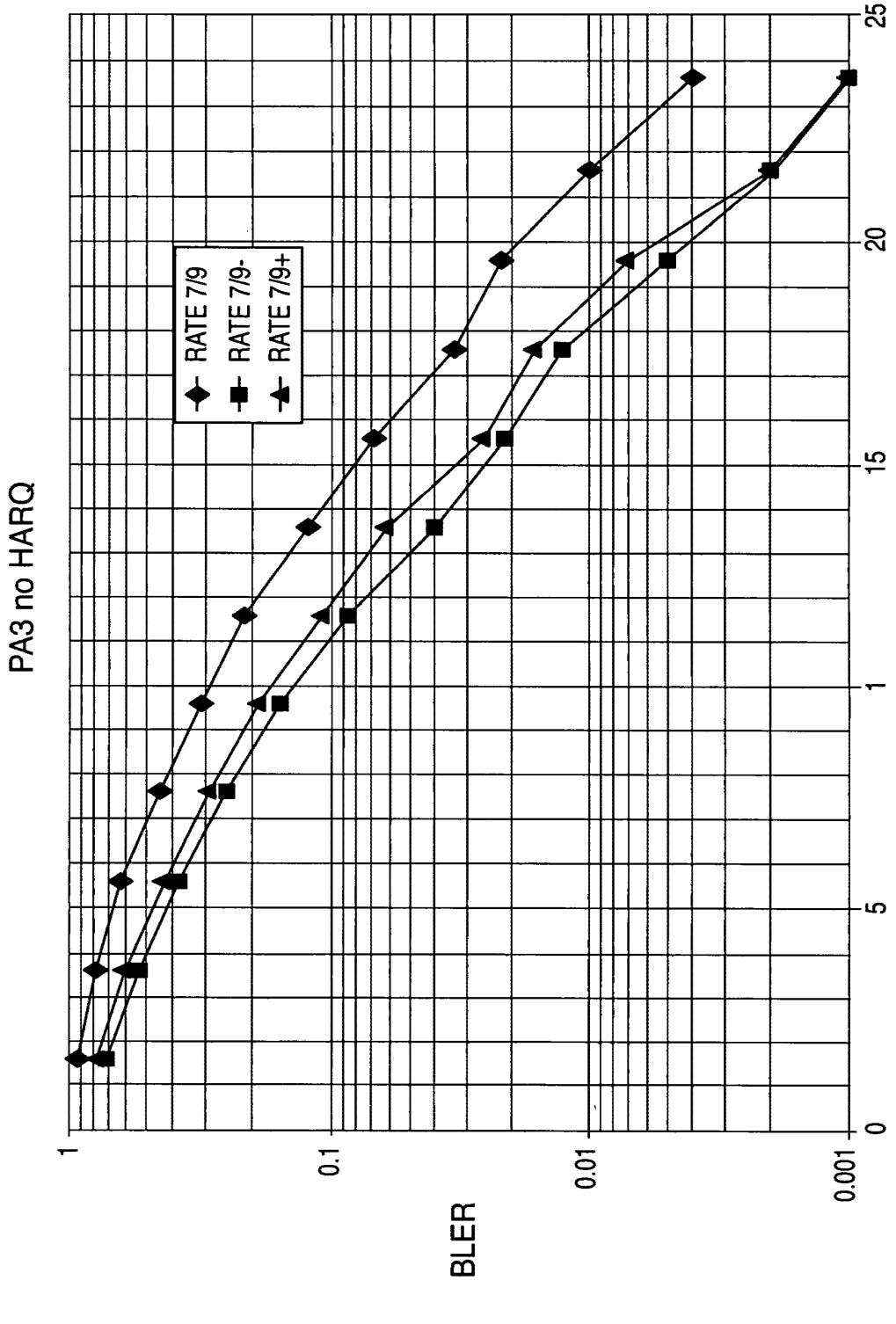

PA3 no HARQ
RATE 7/9
RATE 7/9-
RATE 7/9+
BLER
1
0.1
0.01
0.001
0
5
1
15
20
25
Ior/Ioc

FIG. 11

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☐ Declaration Submitted with Initial Filing OR ☒ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	I-2-0526.1US
First Named Inventor	Pietraski et al.
COMPLETE IF KNOWN	
Application Number	10/725,779
Filing Date	December 2, 2003
Group Art Unit	2183
Examiner Name	Not Yet Known

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES

(Title of the Invention)

the specification of which
☐ is attached hereto
OR
☒ was filed on (MM/DD/YYYY) 12/02/2003 as United States Application Number or PCT International Application Number 10/725,779 and was amended on (MM/DD/YYYY) _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

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Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)
60/434,232	12/16/2002
60/444,068	01/30/2003
60/470,921	05/15/2003
60/494,404	08/11/2003

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U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

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Name	Registration Number	Name	Registration Number
Namely, the Attorneys of Volpe and Koenig, P.C.			

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Name	VOLPE AND KOENIG, P.C. DEPT ICC				
Address					
Address					
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Country		Telephone		Fax	

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname
Philip J.	Pietraski

Inventor's Signature						Date	
Residence: City	Huntington Station	State	NY	Country	USA	Citizenship	USA
Post Office Address	7 Talbot Place						
Post Office Address							
City	Huntington Station	State	NY	ZIP	11746	Country	USA

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ADDITIONAL INVENTOR(S)
Supplemental Sheet
Page 3 of 3

Name of Additional Joint Inventor, if any:	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any])	Family Name or Surname		
Gregory S.	Sternberg		
Inventor's Signature			**Date** 04/28/2009
Residence: City Great Neck	**State** NY	**Country** USA	**Citizenship** USA
Mailing Address 50 Brompton Road, Apartment 2B			
Mailing Address			
City Great Neck	**State** NY	**ZIP** 11021	**Country** USA

Name of Additional Joint Inventor, if any:	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any])	Family Name or Surname		
Inventor's Signature			**Date**
Residence: City	**State**	**Country**	**Citizenship**
Mailing Address			
Mailing Address			
City	**State**	**ZIP**	**Country**

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Inventor's Signature			**Date**
Residence: City	**State**	**Country**	**Citizenship**
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Mailing Address			
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COMPLETE IF KNOWN	
Application Number	10/725,779
Filing Date	December 2, 2003
Group Art Unit	2183
Examiner Name	Not Yet Known

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I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

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☐ is attached hereto
OR
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			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

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60/444,068	01/30/2003
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U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number *(if applicable)*

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OR

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Name	Registration Number	Name	Registration Number
Namely, the Attorneys of Volpe and Koenig, P.C.			

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

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Name	VOLPE AND KOENIG, P.C. DEPT ICC				
Address					
Address					
City		State		ZIP	
Country		Telephone		Fax	

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname
Philip J.	Pietraski

Inventor's Signature						Date	10-5 2004
Residence: City	Huntington Station	State	NY	Country	USA	Citizenship	USA
Post Office Address	7 Talbot Place						
Post Office Address							
City	Huntington Station	State	NY	ZIP	11746	Country	USA

☒ Additional inventors are being named on the 1 supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

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Supplemental Sheet
Page 3 of 3

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Given Name (first and middle [if any])	Family Name or Surname		
Gregory S.	Sternberg		
Inventor's Signature			**Date**
Residence: City Great Neck	**State** NY	**Country** USA	**Citizenship** USA
Mailing Address 50 Brompton Road, Apartment 2B			
Mailing Address			
City Great Neck	**State** NY	**ZIP** 11021	**Country** USA

Name of Additional Joint Inventor, if any:	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any])	Family Name or Surname		
Inventor's Signature			**Date**
Residence: City	**State**	**Country**	**Citizenship**
Mailing Address			
Mailing Address			
City	**State**	**ZIP**	**Country**

Name of Additional Joint Inventor, if any:	☐ A petition has been filed for this unsigned inventor		
Given Name (first and middle [if any])	Family Name or Surname		
Inventor's Signature			**Date**
Residence: City	**State**	**Country**	**Citizenship**
Mailing Address			
Mailing Address			
City	**State**	**ZIP**	**Country**

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APPLICATION DATA SHEET
UNDER 37 CFR §1.76

(1) Inventor Information

Inventor One Given Name::	Philip J.
Family Name::	Pietraski
Postal Address Line One::	7 Talbot Place
City::	Huntington Station
State or Province::	New York
Postal or ZIP Code::	11746
Citizenship Country::	USA
Residence::	Huntington Station, New York, USA

Inventor Two Given Name::	Gregory S.
Family Name::	Sternberg
Postal Address Line One::	7 Brookwood Road
City::	Mt. Laurel
State or Province::	New Jersey
Postal or ZIP Code::	08054
Citizenship Country::	USA
Residence::	Mt. Laurel, New Jersey, USA

(2) Assignee Information

Name Line One::	InterDigital Technology Corporation
Address Line One::	3411 Silverside Road
Address Line Two::	Concord Plaza, Suite 105
City::	Wilmington
State or Province::	Delaware, U.S.A.
Postal or ZIP Code::	19810

(3) Correspondence Information

Customer No.::	24374
Name Line One::	Scott Wolinsky
Name Line Two::	Volpe and Koenig, P.C., DEPT ICC
Telephone No.::	215-568-6400

(4) Application Information

Title Line One::	DETECTION, AVOIDANCE AND/OR
Title Line Two::	CORRECTION OF PROBLEMATIC
Title Line Three::	PUNCTURING PATTERNS IN PARITY BIT
Title Line Four::	STREAMS USED WHEN IMPLEMENTING
Title Line Five::	TURBO CODES
Total Drawing Sheets::	12
Drawing Type::	Formal
Application Type::	Utility
Docket No.::	I-2-0526.2US

(5) Representative Information

Representative Customer No.:: 24374

(6) Domestic Priority Information

This application is a::	Continuation of
>Application One::	10/725,779
Filing Date::	December 2, 2003
which claims the benefit of::	Provisional
>Application Two::	60/434,232
Filing Date::	December 16, 2002
which claims the benefit of::	Provisional
>Application Three::	60/444,068
Filing Date::	January 30, 2003
which claims the benefit of::	Provisional
>Application Four:	60/470,921
Filing Date::	May 15, 2003
which claims the benefit of::	Provisional
>Application Five::	60/494,404
Filing Date::	August 11, 2003

PATENT APPLICATION SERIAL NO._____

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

10/16/2007 SFELEKE1 00000072 11974381

01 FC:1011 310.00 DA
02 FC:1111 510.00 DA
03 FC:1311 210.00 DA
04 FC:1201 210.00 DA

PTO-1556
(5/87)

*U.S. Government Printing Office: 2002- 489-267/69033

PTO/SB/06 (10-07)
Approved for use through 06/30/2010. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 11974381

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	$155		N/A	$310
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	$255		N/A	$510
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	$105		N/A	$210
TOTAL CLAIMS (37 CFR 1.16(i))	9 minus 20 =	* 0	X $25 =		OR	X $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	4 minus 3 =	* 1	X $105 =			X $210 =	210
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $260 ($130 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).		$130			$260	
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			$185			$370	
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1240

APPLICATION AS AMENDED – PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	X $25 =		OR	X $50 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $105 =		OR	X $210 =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					$185		OR	$370	
1, 3, 4, 7						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	X $25 =		OR	X $50 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $105 =		OR	X $210 =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					$185		OR	$370	
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

U.S. PTO
11/974381
10/12/2007

101207 18304 U.S. PTO

PTO/SB/05 (07-07)
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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	I-2-0526.2US
First Inventor	Pietraski et al.
Title	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES
Express Mail Label No.	EV680555714US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. ☑ **Fee Transmittal Form** (e.g., PTO/SB/17)
   (Submit an original and a duplicate for fee processing)
2. ☐ **Applicant claims small entity status.** See 37 CFR 1.27.
3. ☑ **Specification** [*Total Pages* 43]
   Both the claims and abstract must start on a new page
   (For information on the preferred arrangement, see MPEP 608.01(a))
4. ☑ **Drawing(s)** (*35 U.S.C. 113*) [*Total Sheets* 12]
5. **Oath or Declaration** [*Total Sheets* 6]
   a. ☐ Newly executed (original or copy)
   b. ☑ A copy from a prior application (37 CFR 1.63(d))
   (for continuation/divisional with Box 18 completed)
   i. ☐ DELETION OF INVENTOR(S)
   Signed statement attached deleting inventor(s) name in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. ☑ **Application Data Sheet.** See 37 CFR 1.76
7. ☐ **CD-ROM or CD-R** in duplicate, large table or Computer Program *(Appendix)*
   ☐ Landscape Table on CD
8. **Nucleotide and/or Amino Acid Sequence Submission**
   (if applicable, items a. – c. are required)
   a. ☐ Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. ☐ CD-ROM or CD-R (2 copies); or
      ii. ☐ Paper
   c. ☐ Statements verifying identity of above copies

ADDRESS TO:

Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

ACCOMPANYING APPLICATION PARTS

9. ☐ **Assignment Papers** (cover sheet & document(s))
   Name of Assignee_____
10. ☐ **37 CFR 3.73(b) Statement** *(when there is an assignee)* ☐ **Power of Attorney**
11. ☐ **English Translation Document** *(if applicable)*
12. ☐ **Information Disclosure Statement** (PTO/SB/08 or PTO-1449)
    ☐ Copies of citations attached
13. ☐ **Preliminary Amendment**
14. ☑ **Return Receipt Postcard** (MPEP 503)
    (Should be specifically itemized)
15. ☐ **Certified Copy of Priority Document(s)**
    (if foreign priority is claimed)
16. ☐ **Nonpublication Request** under 35 U.S.C. 122(b)(2)(B)(i). Applicant must attach form PTO/SB/35 or equivalent.
17. ☑ Other: Power of Attorney to Customer No. 24374 appears in Declaration.

18. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in the first sentence of the specification following the title, or in an Application Data Sheet under 37 CFR 1.76:*

☑ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No.: 10/725,779

Prior application information: *Examiner* Fritz Alphonse *Art Unit:* 2112

19. CORRESPONDENCE ADDRESS

☑ The address associated with Customer Number: 24374 ***OR*** ☐ Correspondence address below

Name	Volpe and Koenig, P.C., Dept ICC				
Address					
City		State		Zip Code	
Country		Telephone		Email	

Signature	Scott Wolinsky	Date	October 12, 2007
Name (Print/Type)	Scott Wolinsky	Registration No. (Attorney/Agent)	46,413

This collection of information is required by 37 CFR 1.53(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
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101207 18304 U.S. PTO

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PTO/SB/17 (10-07)
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Effective on 12/08/2004.
Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).

FEE TRANSMITTAL
For FY 2008

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 1240

Complete if Known	
Application Number	Not Yet Known
Filing Date	Not Yet Known
First Named Inventor	Pietraski et al.
Examiner Name	Not Yet Known
Art Unit	Not Yet Known
Attorney Docket No.	I-2-0526.2US

METHOD OF PAYMENT (check all that apply)

☐ Check ☐ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): _____

☑ Deposit Account Deposit Account Number: 09-0435 Deposit Account Name: InterDigital Comm. Corp.

For the above-identified deposit account, the Director is hereby authorized to: (check all that apply)

☐ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, **except for the filing fee**

☑ Charge any additional fee(s) or underpayments of fee(s) under 37 CFR 1.16 and 1.17 ☑ Credit any overpayments

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

Application Type	FILING FEES Fee ($)	FILING FEES Small Entity Fee ($)	SEARCH FEES Fee ($)	SEARCH FEES Small Entity Fee ($)	EXAMINATION FEES Fee ($)	EXAMINATION FEES Small Entity Fee ($)	Fees Paid ($)
Utility	310	155	510	255	210	105	1030.00
Design	210	105	100	50	130	65	
Plant	210	105	310	155	160	80	
Reissue	310	155	510	255	620	310	
Provisional	210	105	0	0	0	0	

2. EXCESS CLAIM FEES

Fee Description	Fee ($)	Small Entity Fee ($)
Each claim over 20 (including Reissues)	50	25
Each independent claim over 3 (including Reissues)	210	105
Multiple dependent claims	370	185

Total Claims	Extra Claims	Fee ($)	Fee Paid ($)
9 - 20 or HP =	0	x 0	= 0

HP = highest number of total claims paid for, if greater than 20.

Indep. Claims	Extra Claims	Fee ($)	Fee Paid ($)
4 - 3 or HP =	1	x 210.00	= 210

HP = highest number of independent claims paid for, if greater than 3.

Multiple Dependent Claims Fee ($)	Multiple Dependent Claims Fee Paid ($)
	0

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $260 ($130 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets	Extra Sheets	Number of each additional 50 or fraction thereof	Fee ($)	Fee Paid ($)
- 100 =	0 / 50 =	0 (round up to a whole number) x	0 =	0

4. OTHER FEE(S)

	Fees Paid ($)
Non-English Specification, $130 fee (no small entity discount)	
Other (e.g., late filing surcharge):	0

SUBMITTED BY

Signature	Scott Wolinsky	Registration No. (Attorney/Agent) 46,413	Telephone 215-568-6400
Name (Print/Type)	Scott Wolinsky		Date October 12, 2007

This collection of information is required by 37 CFR 1.136. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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PTO/SB/06 (12-04)

Filing Date: 10/12/07

Approved for use through 7/31/2006. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 11/974,381

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	310
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	510
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	210
TOTAL CLAIMS (37 CFR 1.16(i))	9 minus 20=	0	X$ 25		OR	X$50	0
INDEPENDENT CLAIMS (37 CFR 1.16(h))	4 minus 3 =	* 1	X$105			X$210	210
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			185			370	
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	0		TOTAL	1240

APPLICATION AS AMENDED – PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	X =		OR	X =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X =		OR	X =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
						TOTAL ADD'T FEE		OR	TOTAL ADD'T FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	X =		OR	X =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X =		OR	X =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
						TOTAL ADD'T FEE		OR	TOTAL ADD'T FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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