UNITED STATES
PATENT AND TRADEMARK OFFICE

13/744,984 | I-2-0526US05:

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
13/744,984	I-2-0526US05	8,788,920 Issued - 07/22/2014	Patented Case - 07/02/2014	01/18/2013

Documents & transaction history

Documents

Mail room date	Doc code	Doc description	Pages	Quick download
07/16/2014	APP.FILE.REC	Filing Receipt	3	
07/16/2014	N570	Communication - Re: Power of Attorney (PTOL-308)	1	
07/10/2014	N570	Communication - Re: Power of Attorney (PTOL-308)	1	
07/08/2014	APP.FILE.REC	Filing Receipt	3	
07/08/2014	PA..	Power of Attorney	2	
07/08/2014	N417	Electronic Filing System(EFS) Acknowledgment Receipt	2	
07/08/2014	CFILE	Request for Corrected Filing Receipt	2	
07/08/2014	ADS	Application Data Sheet	7	
07/02/2014	ISSUE.NTF	Issue Notification	1	
06/12/2014	APP.FILE.REC	Filing Receipt	4	
06/10/2014	IFEE	Issue Fee Payment (PTO-85B)	1	
06/10/2014	WFEE	Fee Worksheet (SB06)	2	

Mail room date	Doc code	Doc description	Pages	Quick download
06/10/2014	N417	Electronic Filing System(EFS) Acknowledgment Receipt	2	
03/11/2014	NOA	Notice of Allowance and Fees Due (PTOL-85)	5	
03/11/2014	ANE.I	Amendment After Final or under 37CFR 1.312, initialed by the examiner.	1	
03/11/2014	SRNT	Examiner's search strategy and results	5	
03/11/2014	BIB	Bibliographic Data Sheet	1	
03/11/2014	FWCLM	Index of Claims	1	
03/11/2014	IIFW	Issue Information including classification, examiner, name, claim, renumbering, etc.	3	
03/11/2014	SRFW	Search information including classification, databases and other search related notes	1	
03/11/2014	1449	List of References cited by applicant and considered by examiner	4	
02/26/2014	DISQ	Terminal Disclaimer review decision	1	
02/05/2014	A...	Amendment/Request for Reconsideration-After Non-Final Rejection	1	
02/05/2014	REM	Applicant Arguments/Remarks Made in an Amendment	2	
02/05/2014	TRAN.LET	Transmittal Letter	2	
02/05/2014	ADS	Application Data Sheet	7	
02/05/2014	R3.73	Assignee showing of ownership per 37 CFR 3.73	3	
02/05/2014	DIST	Terminal Disclaimer Filed	2	
02/05/2014	N417	Electronic Filing System(EFS) Acknowledgment Receipt	3	
12/05/2013	CTFR	Final Rejection	5	
12/05/2013	SRFW	Search information including classification, databases and other search related notes	1	
12/05/2013	SRNT	Examiner's search strategy and results	5	
12/05/2013	FWCLM	Index of Claims	1	

Mail room date	Doc code	Doc description	Pages	Quick download
10/16/2013	DISQ	Terminal Disclaimer review decision	1	
10/09/2013	PEFN	Pre-Exam Formalities Notice	1	
10/09/2013	N572	Response - Re: Informal Power of Attorney (PTOL-308)	2	
10/07/2013	DIST	Terminal Disclaimer Filed	2	
10/07/2013	XT/	Extension of Time	2	
10/07/2013	PA..	Power of Attorney	1	
10/07/2013	R3.73	Assignee showing of ownership per 37 CFR 3.73	3	
10/07/2013	WFEE	Fee Worksheet (SB06)	2	
10/07/2013	N417	Electronic Filing System(EFS) Acknowledgment Receipt	3	
10/07/2013	A...	Amendment/Request for Reconsideration-After Non-Final Rejection	1	
10/07/2013	CLM	Claims	4	
10/07/2013	REM	Applicant Arguments/Remarks Made in an Amendment	3	
10/07/2013	LET.	Miscellaneous Incoming Letter	2	
07/03/2013	IDS	Information Disclosure Statement (IDS) Form (SB08)	4	
07/03/2013	FOR	Foreign Reference	16	
07/03/2013	FOR	Foreign Reference	166	
07/03/2013	NPL	Non Patent Literature	3	
07/03/2013	WFEE	Fee Worksheet (SB06)	2	
07/03/2013	N417	Electronic Filing System(EFS) Acknowledgment Receipt	3	
07/03/2013	TRAN.LET	Transmittal Letter	3	
06/15/2013	OA.POSTCARD	A courtesy postcard sent by USPTO to users who opt-in for e-Office Action	1	
06/07/2013	CTNF	Non-Final Rejection	5	
06/07/2013	892	List of references cited by examiner	1	

Mail room date	Doc code	Doc description	Pages	Quick download
06/07/2013	SRFW	Search information including classification, databases and other search related notes	1	
06/07/2013	1449	List of References cited by applicant and considered by examiner	4	
06/07/2013	SRNT	Examiner's search strategy and results	4	
06/07/2013	FWCLM	Index of Claims	1	
05/30/2013	NTC.PUB	Notice of Publication	1	
05/28/2013	SRNT	Examiner's search strategy and results	1	
04/26/2013	SRNT	Examiner's search strategy and results	1	
04/05/2013	OATH	Oath or Declaration filed	2	
04/05/2013	N417	Electronic Filing System(EFS) Acknowledgment Receipt	2	
02/19/2013	APP.FILE.REC	Filing Receipt	4	
02/19/2013	M327	Miscellaneous Communication to Applicant - No Action Count	1	
02/19/2013	WFEE	Fee Worksheet (SB06)	1	
02/13/2013	IDS	Information Disclosure Statement (IDS) Form (SB08)	4	
02/13/2013	N417	Electronic Filing System(EFS) Acknowledgment Receipt	2	
02/13/2013	TRAN.LET	Transmittal Letter	3	
01/18/2013	SPEC	Specification	41	
01/18/2013	CLM	Claims	4	
01/18/2013	ABST	Abstract	1	
01/18/2013	DRW	Drawings-only black and white line drawings	12	
01/18/2013	ADS	Application Data Sheet	7	
01/18/2013	WFEE	Fee Worksheet (SB06)	2	
01/18/2013	N417	Electronic Filing System(EFS) Acknowledgment Receipt	3	

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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
13/744,984	01/18/2013	2112	1390	I-2-0526US05	14	2

CONFIRMATION NO. 9610

CORRECTED FILING RECEIPT

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

OC00000069578215

Date Mailed: 07/16/2014

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

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

Applicant(s)

INTERDIGITAL TECHNOLOGY CORPORATION, Wilmington, DE

Power of Attorney: The patent practitioners associated with Customer Number 24374

Domestic Priority data as claimed by applicant

This application is a CON of 13/309,962 12/02/2011 PAT 8359520
which is a CON of 11/974,381 10/12/2007 PAT 8074143
which is a CON of 10/725,779 12/02/2003 PAT 7293217
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 for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

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The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/744,984**

Projected Publication Date: Not Applicable

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

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Title 37, Code of Federal Regulations, 5.11 & 5.15

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/744,984	01/18/2013	Philip J. Pietraski	I-2-0526US05

CONFIRMATION NO. 9610

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

POA ACCEPTANCE LETTER

OC000000069578209

Date Mailed: 07/16/2014

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 07/08/2014.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/rmohamed/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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24374
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30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103

POA ACCEPTANCE LETTER

OC000000069460274

Date Mailed: 07/10/2014

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/07/2013.

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/rmohamed/

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CONFIRMATION NO. 9610

CORRECTED FILING RECEIPT

24374
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UNITED PLAZA
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PHILADELPHIA, PA 19103

OC000000069456428

Date Mailed: 07/08/2014

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

Applicant(s)

INTERDIGITAL TECHNOLOGY CORPORATION, Wilmington, DE

Assignment For Published Patent Application

INTERDIGITAL TECHNOLOGY CORPORATION, Wilmington, DE

Power of Attorney: None

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which is a CON of 10/725,779 12/02/2003 PAT 7293217
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Projected Publication Date: Not Applicable

Non-Publication Request: No

Early Publication Request: No

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Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
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NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	13/744,984
Filing Date	January 18, 2013
First Named Inventor	Philip J. Pietraski
Title	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES
Art Unit	2112
Examiner Name	Fritz Alphonse
Attorney Docket Number	I-2-0526US05

SIGNATURE of Applicant or Patent Practitioner

Signature	/Jonathan G. Lombardo/	Date (Optional)	July 8, 2014
Name	Jonathan G. Lombardo	Registration Number	71,734
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)	InterDigital Technology Corporation		

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of one (1) forms are submitted.

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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 24374

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

InterDigital Technology Corporation

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature	C Ioannidi	Date (Optional)	13 March 2014
Name	Christos A. Ioannidi		
Title	Patent Executive; InterDigital Technology Corporation		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ Total of forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. 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 3 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.

Electronic Acknowledgement Receipt	
EFS ID:	19515434
Application Number:	13744984
International Application Number:	
Confirmation Number:	9610
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:	Jonathan G. Lombardo/Belinda Fields
Filer Authorized By:	Jonathan G. Lombardo
Attorney Docket Number:	I-2-0526US05
Receipt Date:	08-JUL-2014
Filing Date:	18-JAN-2013
Time Stamp:	14:02:22
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	I_2_0526US05_Request_For_Corrected_Filing_Receipt.PDF	69877 6dfcc6fb582fdfab8becef5d0c9c35e5f1226ab7	no	2
Warnings:					
Information:					

2	Application Data Sheet	I_2_0526US05_ADS_20140708.PDF	577419 199211864ad1824c5aad8d8be2eb6f9cbb43f58d	no	7
Warnings:					
Information:					
This is not an USPTO supplied ADS fillable form					
3	Power of Attorney	I_2_0526US05_Power_Of_Attorney_20140708.PDF	292836 a23ed4d16db9345c0b7451d638a7c93a71b026fb	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	940132		

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.:	**13/744,984**
Confirmation No.:	**9610**
Filed:	January 18, 2013
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-2-0526US05

Date: July 8, 2014

REQUEST FOR CORRECTED FILING RECEIPT

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

Madam:

This request is in response to an error indicated on the Filing Receipt sent on June 12, 2014 and to clarify the Power of Attorney.

After discussing the errors with the Application Assistance Unit (AAU), they recommend amending the Application Data Sheet (ADS) by filing a supplemental ADS to correct the error on the Filing Receipt and Power of Attorney which currently shows "none" for the Power of Attorney.

3141095-1

A corrected Application Data Sheet and a copy of the Power of Attorney are enclosed.

Accordingly, Applicants respectfully request the issuance of a corrected Filing Receipt and a Notice of Acceptance of Power of Attorney.

Respectfully submitted,

Pietraski et al.

By /Jonathan G. Lombardo/
Jonathan G. Lombardo
Registration No. 71,734

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

JGL/JDW/bbf
Enclosures

PTO/AIA/14 (12-13)
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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	13/744,984
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Philip	J.	Pietraski	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Jericho	State/Province	NY	Country of Residence	US

Mailing Address of Inventor:

Address 1	39 Marian Lane		
Address 2			
City	Jericho	State/Province	NY
Postal Code	11753	Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Gregory	S.	Sternberg	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Mt. Laurel	State/Province	NJ	Country of Residence	US

Mailing Address of Inventor:

Address 1	7 Brookwood Road		
Address 2			
City	Mt. Laurel	State/Province	NJ
Postal Code	08054	Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

PTO/AIA/14 (12-13)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	13/744,984
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

☐ An Address is being provided for the correspondence Information of this application.			
Customer Number	24374		
Email Address	eoffice@vklaw.com	Add Email	Remove Email

Application Information:

Title of the Invention	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES		
Attorney Docket Number	I-2-0526US05	**Small Entity Status Claimed**	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	12	**Suggested Figure for Publication (if any)**	8

Filing By Reference :

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	24374		

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	13/744,984
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the application number blank.

Prior Application Status	~~Patented~~ Pending	Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
	Continuation of	13309962	2011-12-02	8359520	2013-01-22

Prior Application Status	Patented	Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
13309962	Continuation of	11974381	2007-10-12	8074143	2011-12-06

Prior Application Status	Patented	Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
11974381	Continuation of	10725779	2003-12-02	7293217	2007-11-06

Prior Application Status	Expired	Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
10725779	Claims benefit of provisional	60494404	2003-08-11

Prior Application Status	Expired	Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
10725779	Claims benefit of provisional	60470921	2003-05-15

Prior Application Status	Expired	Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
10725779	Claims benefit of provisional	60444068	2003-01-30

Prior Application Status	Expired	Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
10725779	Claims benefit of provisional	60434232	2002-12-16

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

PTO/AIA/14 (12-13)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	13/744,984
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Remove Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Authorization to Permit Access:

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date o f filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

PTO/AIA/14 (12-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	13/744,984
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. ☒

Organization Name	INTERDIGITAL TECHNOLOGY CORPORATION

Mailing Address Information For Applicant:

Address 1	200 Bellevue Parkway		
Address 2	Suite 300		
City	Wilmington	**State/Province**	DE
Country	US	Postal Code	19809
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button.

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication . An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☒

PTO/AIA/14 (12-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	13/744,984
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

Organization Name	~~INTERDIGITAL TECHNOLOGY CORPORATION~~		
Mailing Address Information For Assignee including Non-Applicant Assignee:			
Address 1	~~200 Bellevue Parkway~~		
Address 2	~~Suite 300~~		
City	~~Wilmington~~	**State/Province**	~~DE~~
Country i	~~US~~	Postal Code	~~19809~~
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Signature	/Jonathan G. Lombardo/			Date (YYYY-MM-DD)	2014-07-08
First Name	Jonathan G.	Last Name	Lombardo	Registration Number	71734

Additional Signature may be generated within this form by selecting the Add button.

This collection of information is required by 37 CFR 1.76. 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 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet 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.**

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 the Freedom of Information Act requires disclosure of these records.

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.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

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 C o o p eration 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 inspections 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.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/744,984	07/22/2014	8788920	I-2-0526US05	9610

24374 7590 07/02/2014

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 0 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, NY;
INTERDIGITAL TECHNOLOGY CORPORATION, Wilmington, DE
Gregory S. Sternberg, Mt. Laurel, NJ;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

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P.O. Box 1450
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www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/744,984	01/18/2013	2112	1390	I-2-0526US05	14	2

CONFIRMATION NO. 9610

CORRECTED FILING RECEIPT

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

OC00000068974563

Date Mailed: 06/12/2014

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

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

Applicant(s)

INTERDIGITAL TECHNOLOGY CORPORATION, Wilmington, DE

Assignment For Published Patent Application

INTERDIGITAL TECHNOLOGY CORPORATION, Wilmington, DE

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 13/309,962 12/02/2011 PAT 8359520 *
which is a CON of 11/974,381 10/12/2007 PAT 8074143
which is a CON of 10/725,779 12/02/2003 PAT 7293217
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
(*)Data provided by applicant is not consistent with PTO records.

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access - A proper **Authorization to Permit Access to Application by Participating Offices** (PTO/SB/39 or its equivalent) has been received by the USPTO.

If Required, Foreign Filing License Granted: 02/09/2013

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/744,984**

Projected Publication Date: Not Applicable

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

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications:

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
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Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

24374 7590 03/11/2014
VOLPE AND KOENIG, P.C.
DEPT. ICC
UNITED PLAZA
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

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

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/744,984	01/18/2013	Philip J. Pietraski	I-2-0526US05	9610

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

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	06/11/2014

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

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "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, DE

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:
- ☒ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number 09-0435 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ☐ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ☐ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Wesley T. McMichael/ Date June 10, 2014
Typed or printed name Wesley T. McMichael Registration No. 56,982

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Electronic Patent Application Fee Transmittal

Application Number:	13744984
Filing Date:	18-Jan-2013
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:	Wesley T. McMichael/Belinda Fields
Attorney Docket Number:	I-2-0526US05

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	960	960
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**960**

Electronic Acknowledgement Receipt	
EFS ID:	19261624
Application Number:	13744984
International Application Number:	
Confirmation Number:	9610
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:	Wesley T. McMichael/Belinda Fields
Filer Authorized By:	Wesley T. McMichael
Attorney Docket Number:	I-2-0526US05
Receipt Date:	10-JUN-2014
Filing Date:	18-JAN-2013
Time Stamp:	15:59:34
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$960
RAM confirmation Number	2643
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 1.17 (Patent application and reexamination processing fees) Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)	

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)					
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_0526US05_Issue_Fee_20140610.PDF	97062 64e11c46494f77703e8f2601faf4de29cd513153	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30687 bd80740ed161e97cb5489205a2ac701540316cc0	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	127749		

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.

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NOTICE OF ALLOWANCE AND FEE(S) DUE

24374 7590 03/11/2014

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: 03/11/2014

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/744,984	01/18/2013	Philip J. Pietraski	I-2-0526US05	9610

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

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	06/11/2014

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE 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.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

24374 7590 03/11/2014
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DEPT. ICC
UNITED PLAZA
30 SOUTH 17TH STREET
PHILADELPHIA, PA 19103

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

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

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/744,984	01/18/2013	Philip J. Pietraski	I-2-0526US05	9610

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

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nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	06/11/2014

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

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "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 _____
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 (B) RESIDENCE: (CITY and STATE OR COUNTRY)

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:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ❑ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/744,984	01/18/2013	Philip J. Pietraski	I-2-0526US05	9610

24374 7590 03/11/2014

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: 03/11/2014

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 0 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 0 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.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B 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. 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.

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.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
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. 13/744,984	Applicant(s) PIETRASKI ET AL.	
	Examiner FRITZ ALPHONSE	Art Unit 2112	AIA (First Inventor to File) Status No

-- 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 Terminal Disclaimer filed on 02/05/2014*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
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 *1-14*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   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. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ 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).
6. ☐ 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. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 07/03/2013
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/FRITZ ALPHONSE/
Primary Examiner, Art Unit 2112

OK TO ENTER: /F.A./

02/28/2014

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the **PATENT APPLICATION** of:	
Pietraski et al.	
Application No.:13/744,984	
Confirmation No.:9610	
Filed: January 18, 2013	Our File: I-2-0526US05
For: DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	Date: February 5, 2014
Group: 2112	
Examiner: Fritz Alphonse	

REPLY PURSUANT TO 37 C.F.R. §1.116

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

Madam:

This Reply is in response to the Final Office Action dated December 5, 2013.

2876598-1

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	0	(rate matching wireless communication terminal interleav$4 bit stream buffer$4 virtual buffer output).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2014/02/28 12:39
L2	1168	(rate matching wireless communication terminal interleav$4 bit stream buffer$4 virtual buffer output)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2014/02/28 12:40
L3	4801	714/790,774,786,752,755,800.ccls.	USPAT	OR	OFF	2014/02/28 12:40
L4	10	2 3	USPAT	AND	OFF	2014/02/28 12:41
L5	0	4 and interleav$4 near4 ("first bit" and "second bit" and "third bit")	USPAT	AND	OFF	2014/02/28 12:42
S1	233	(rate matching interleav$4 bit stream)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/29 11:38
S2	0	(buffer$4 interleav bit stream virtual buffer)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/29 11:40
S3	31	(buffer$4 interleav$4 bit stream virtual buffer)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/29 11:40
S4	19	S1 S3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/05/29 11:40
S5	9124	virtual near4 buffer	US-PGPUB; USPAT;	SAME	OFF	2013/05/31 23:09

			USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			
S6	0	virtual adj buffer is a physical adj buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/31 23:24
S7	92	virtual adj buffer same physical adj buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/31 23:24
S8	14	(rate matching interleav$4 bit stream buffer$4 virtual buffer)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/31 23:45
S9	162	("20020051501" "6088387" "6028897" "6014411" "6044116" "6370669" "6397367" "6622281" "6665833" "6697986" "6744744" "6807238" "6816556" "6829305" "6892342" "6903665" "7016427" "7016658" "7027782" "7072307" "7089480" "7146552" "7165209" "7200792" "7210089" "7251285" "7280609" "7283509" "7293217" "7415263" "7421033" "7458011" "7483389" "7496079" "7523383" "7536624" "7620872" "7640486" "7673213" "7676731" "7676732" "7743312" RE41498 "7782973" "7802164" "7814390" "7814391" "7827466" "7925963" "7958425" "7987414" "8074143" "7925963" "7958425" "7987414" "8074143" "8250429" "8254284" "8275032" "8359520" "8386877" "8416794" "20010009569" "20010010710" "20010034209" "20020015419" "20020027956" "20020166093" "20030007476" "20030021240" "20030031233" "20030076870" "20030097629" "20030120995" "20030135811" "20030171121" "20040125765" "20040139378" "20040146029" "20040184553" "20040187069" "20040187070" "20040257992" "20050053168" "20050100085" "20050100103" "20050172201" "20050172202" "20050204251" "20050216819" "20050283710" "20060031737" "20060150051" "20060179401" "20060190801" "20060206781"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:13

		"20060239237" "20060251001" "20070089025" "20070101232").pn.				
S10	14	(rate matching interleav$4 bit stream buffer$4 virtual buffer)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/06/01 13:16
S11	92	virtual adj buffer same physical adj buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/06/01 13:17
S12	0	S9 S10 S11	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/01 13:17
S13	76	S9 and rate near4 matching	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/01 13:27
S14	47	S13 and interleav$4 bit near4 stream	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/01 13:27
S15	1	S14 and buffer$4 interleav$4 bit stream	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/06/01 13:29
S16	1	S9 and buffer$4 interleav$4 bit stream	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/06/01 13:50
S17	1	S10 S14	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/01 13:51
S18	0	S9 and S11	US-PGPUB; USPAT; USOCR;	OR	OFF	2013/06/01 13:51

			FPRS; EPO; JPO; DERWENT; IBM_TDB			
S19	76	S9 and S13	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:51
S20	0	S19 and mate same matching	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:58
S21	76	S19 and rate same matching	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:58
S22	7177	"16" and virtual near4 buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:58
S23	11	S21 and virtual near4 buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:58
S24	44	S13 and "714"/$.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 14:11
S25	163	("20020051501" "6088387" "6028897" "6014411" "6044116" "6370669" "6397367" "6622281" "6665833" "6697986" "6744744" "6807238" "6816556" "6829305" "6892342" "6903665" "7016427" "7016658" "7027782" "7072307" "7089480" "7146552" "7165209" "7200792" "7210089" "7251285" "7280609" "7283509" "7293217" "7415263" "7421033" "7458011" "7483389" "7496079" "7523383" "7536624" "7620872" "7640486" "7673213" "7676731" "7676732" "7743312" RE41498 "7782973" "7802164" "7814390" "7814391" "7827466" "7925963"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/12/02 10:58

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S26	15	(rate matching interleav$4 bit stream buffer$4 virtual buffer)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/12/02 10:59
S27	1	S25 S26	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/12/02 10:59

2/28/2014 12:43:11 PM
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BIB DATA SHEET

CONFIRMATION NO. 9610

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/744,984	01/18/2013	714	2112	I-2-0526US05

APPLICANTS

INVENTORS

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

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

This application is a CON of 13/309,962 12/02/2011 PAT 8359520 *
which is a CON of 11/974,381 10/12/2007 PAT 8074143
which is a CON of 10/725,779 12/02/2003 PAT 7293217
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
(*)Data provided by applicant is not consistent with PTO records.

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

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

02/09/2013

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	14	2

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		
1390	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13744984	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	02/28/2014								
	1	=								
	2	=								
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	13	=								
	14	=								

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13744984	PIETRASKI ET AL.
	Examiner	**Art Unit**
	FRITZ ALPHONSE	2112

CPC		
Symbol	**Type**	**Version**

CPC Combination Sets				
Symbol	**Type**	**Set**	**Ranking**	**Version**

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	14	
/FRITZ ALPHONSE/ Primary Examiner.Art Unit 2112	2/28/2014	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	10

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13744984	PIETRASKI ET AL.
	Examiner	**Art Unit**
	FRITZ ALPHONSE	2112

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION												
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED							
714	790	H	0	3	M	13 / 03 (2006.01.01)								
CROSS REFERENCE(S)														
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)													
714	774	786												

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	14	
/FRITZ ALPHONSE/ Primary Examiner.Art Unit 2112	2/28/2014	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	10

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13744984	PIETRASKI ET AL.
	Examiner	**Art Unit**
	FRITZ ALPHONSE	2112

☒ 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
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	13														
	14														

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 14	
/FRITZ ALPHONSE/ Primary Examiner.Art Unit 2112	2/28/2014	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	10

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13744984	PIETRASKI ET AL.
	Examiner	Art Unit
	FRITZ ALPHONSE	2112

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
714	790,774,786,752,755,800	2/28/2014	FA

SEARCH NOTES		
Search Notes	Date	Examiner
East Search	2/28/2014	FA
Plus Search (See East Search)	2/28/2014	FA

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
714/H03M	790/13/03	2/28/2014	FA

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

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

02/28/2014

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	13744984
	Filing Date	2013-01-18
	First Named Inventor	Pietraski et al.
	Art Unit	2112
	Examiner Name	Fritz Alphonse
	Attorney Docket Number	I-2-0526US05

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
/F.A./	1	20020004478	KR	A	2002-01-16	LG ELECTRONICS INC	* English abstract provided	☐
/F.A./	2	0048353	WO	A1	2000-08-17	HUGHES ELECTRONICS CORP	* Corresponds to KR 20010052246	☐

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13744984
	Filing Date	2013-01-18
	First Named Inventor	Pietraski et al.
	Art Unit	2112
	Examiner Name	Fritz Alphonse
	Attorney Docket Number	I-2-0526US05

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1		☐

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EXAMINER SIGNATURE

Examiner Signature	/Fritz Alphonse/	Date Considered	02/28/2014

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

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13744984
	Filing Date	2013-01-18
	First Named Inventor	Pietraski et al.
	Art Unit	2112
	Examiner Name	Fritz Alphonse
	Attorney Docket Number	I-2-0526US05

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Wesley T. McMichael/	Date (YYYY-MM-DD)	2013-07-03
Name/Print	Wesley T. McMichael	Registration Number	56,982

This collection of information is required by 37 CFR 1.97 and 1.98. 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 1 hour 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.**

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 the Freedom of Information Act requires disclosure of these record s.

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.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

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 inspections 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.

Application Number	Application/Control No.	Applicant(s)/Patent under Reexamination	
	13/744,984	PIETRASKI ET AL.	

Document Code - DISQ	Internal Document – DO NOT MAIL

TERMINAL DISCLAIMER	☒ APPROVED	☐ DISAPPROVED
Date Filed : 2/05/14	This patent is subject to a Terminal Disclaimer	

Approved/Disapproved by:

jean proctor

U.S. Patent and Trademark Office

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the **PATENT APPLICATION** of:	
Pietraski et al.	
Application No.:13/744,984	
Confirmation No.:9610	
Filed: January 18, 2013	Our File: I-2-0526US05
For: DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	Date: February 5, 2014
Group: 2112	
Examiner: Fritz Alphonse	

REPLY PURSUANT TO 37 C.F.R. §1.116

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

Madam:

This Reply is in response to the Final Office Action dated December 5, 2013.

REMARKS/ARGUMENTS

After the foregoing Amendment, claims 1-14 are currently pending in this application.

In response to the Final Office Action, a corrected Application Data Sheet, a Terminal Disclaimer and a new Statement Under 3.73(c) is enclosed.

Accordingly, Applicants respectfully request the issuance of a Notice of Acceptance of Power of Attorney.

Double Patenting Rejection

Claims 1-7, 13-14 and 8-12 are rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-8 of U.S. Patent No. 8,074,143. A Terminal Disclaimer is submitted herewith to overcome the nonstatutory obviousness-type double patenting rejection. The withdrawal of the nonstatutory obviousness-type double patenting rejection is respectfully requested.

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 /Jonathan G. Lombardo/
Jonathan G. Lombardo
Registration No. 71,734

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

JGL/JDW/bbf
Enclosures

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the **PATENT APPLICATION** of:	
Pietraski et al.	
Application No.:13/744,984	
Confirmation No.:9610	
Filed: January 18, 2013	Our File: I-2-0526US05
For: DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	Date: February 5, 2014
Group: 2112	
Examiner: Fritz Alphonse	

REQUEST TO CORRECT APPLICATION DATA SHEET

Commissioner for Patents (VIA EFS)
P.O. Box 1450
Alexandria, VA 22313-1450

Madam:

In reference to the above-identified application enclosed is a marked-up Application Data Sheet. The new marked up Application Data Sheet specifies the correct name of the Applicant in the Applicant Information section.

The new marked up Application Data Sheet also corrects Domestic Benefit priority information and provides an updated address in the Inventor 1 section.

2876695-1

Applicants respectfully request that the changes be made as requested in the Application Data Sheet.

Respectfully submitted,

Pietraski et al.

By /Jonathan G. Lombardo/
Jonathan G. Lombardo
Registration No. 71,734

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

JGL/JDW/bbf
Enclosures

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	13/744,984
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTON OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Philip	J.	Pietraski	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	~~Huntington~~ Jericho	State/Province	NY	Country of Residence	US ~~NY~~

Mailing Address of Inventor:

Address 1	~~7 Talbot Place~~ 39 Marian Lane
Address 2	

City	~~Huntington~~ Jericho	State/Province	NY
Postal Code	~~11746~~ 11753	Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Gregory	S.	Sternberg	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Mt. Laurel	State/Province	NJ	Country of Residence	US

Mailing Address of Inventor:

Address 1	7 Brookwood Road
Address 2	

City	Mt. Laurel	State/Province	NJ
Postal Code	08054	Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	13/744,984
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTON OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	24374		
Email Address	eoffice@vklaw.com	Add Email	Remove Email

Application Information:

Title of the Invention	DETECTION, AVOIDANCE AND/OR CORRECTON OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES		
Attorney Docket Number	I-2-0526US05	**Small Entity Status Claimed**	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	12	**Suggested Figure for Publication (if any)**	8

Filing By Reference :

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	24374		

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	13/744,984
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTON OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the application number blank.

Prior Application Status	Patented ~~Pending~~			Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
	Continuation of	13309962	2011-12-02	8359520	2013-01-22
Prior Application Status	Patented			Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
13309962	Continuation of	11974381	2007-10-12	8074143	2011-12-06
Prior Application Status	Patented			Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
11974381	Continuation of	10725779	2003-12-02	7293217	2007-11-06 ~~2012-12-30~~
Prior Application Status	Expired ~~Patented~~			Remove	
Application Number	Continuity Type		Prior Application Number	Filing Date (YYYY-MM-DD)	
10725779	Claims benefit of provisional		60494404	2003-08-11	
Prior Application Status	Expired ~~Patented~~			Remove	
Application Number	Continuity Type		Prior Application Number	Filing Date (YYYY-MM-DD)	
10725779	Claims benefit of provisional		60470921	2003-05-15	
Prior Application Status	Expired ~~Patented~~			Remove	
Application Number	Continuity Type		Prior Application Number	Filing Date (YYYY-MM-DD)	
10725779	Claims benefit of provisional		60444068	2003-01-30	
Prior Application Status	Expired ~~Patented~~			Remove	
Application Number	Continuity Type		Prior Application Number	Filing Date (YYYY-MM-DD)	
10725779	Claims benefit of provisional		60434232	2002-12-16	

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[1] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	13/744,984
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTON OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Remove Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Authorization to Permit Access:

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date o f filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTON OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. ☒

Organization Name	INTERDIGITAL TECHNOLOGY CORPORATION		
Mailing Address Information For Applicant:			
Address 1	200 Bellevue Parkway		
Address 2	Suite 300		
City	Wilmington	**State/Province**	DE
Country	US	Postal Code	19809
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button.

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication . An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☒

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTON OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

Organization Name	INTERDIGITAL TECHNOLOGY CORPORATION

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1	200 Bellevue Parkway		
Address 2	Suite 300		
City	Wilmington	**State/Province**	DE
Country i	US	Postal Code	19809
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Signature	/Jonathan G. Lombardo/			Date (YYYY-MM-DD)	2014-02-05
First Name	Jonathan G.	Last Name	Lombardo	Registration Number	71734

Additional Signature may be generated within this form by selecting the Add button.

This collection of information is required by 37 CFR 1.76. 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 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet 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.**

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 the Freedom of Information Act requires disclosure of these records.

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.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

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 C o o p eration 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 inspections 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.

PTO/AIA/96 (08-12)
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STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Pietraski et al.

Application No./Patent No.: 13/744,984 Filed/Issue Date: January 18, 2013

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

InterDigital Technology Corporation, a corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

   ☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☑ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 014684, Frame 0352, or for which a copy thereof is attached.

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____

   The document was recorded in the United States Patent and Trademark Office at

   Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____

   The document was recorded in the United States Patent and Trademark Office at

   Reel _____, Frame _____, or for which a copy thereof is attached.

This collection of information is required by37 CFR3.73(b). The information is required toobtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentialityis governed by35 U.S.C. 122and 37 CFR1.11 and1.14. Thiscollection is estimated to take 12 minutes to complete, including gathering, preparing, and submittingthe 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 tothe 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.

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STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☐ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Jonathan G. Lombardo/	February 5, 2014
Signature	Date
Jonathan G. Lombardo	71,734
Printed or Typed Name	Title or Registration Number

Privacy Act Statement

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9. A record from thissystem 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.

PTO/AIA/26 (04-13)
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TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT	Docket Number (Optional) I-2-0526US05

In re Application of: Pietraski et al.

Application No.: 13/744,984

Filed: January 18, 2013

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

The applicant, InterDigital Technology Corporation, owner of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of **prior patent** No. 8,074,143 as the term of said **prior patent** is presently shortened by any terminal disclaimer. The applicant hereby agrees that any patent so granted on the instant application shall be enforceable only for any during such period that it and the **prior patent** are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the applicant does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term of the **prior patent**, "as the term of said **prior patent** is presently shortened by any terminal disclaimer," in the event that said **prior patent** later:

expires for failure to pay a maintenance fee;
is held unenforceable;
is found invalid by a court of competent jurisdiction;
is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
has all claims canceled by a reexamination certificate;
is reissued; or
is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

Check either box 1 or 2 below, if appropriate.

1. ☐ The undersigned is the applicant. If the applicant is an assignee, the undersigned is authorized to act on behalf of the assignee.

I hereby acknowledge that any willful false statements made are punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

2. ☑ The undersigned is an attorney or agent of record. Reg. No. 71,734

/Jonathan G. Lombardo/ — Signature
February 5, 2014 — Date

Jonathan G. Lombardo — Typed or printed name

Attorney — Title
215-568-6400 — Telephone Number

☐ Terminal disclaimer fee under 37 CFR 1.20(d) included.

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.

This collection of information is required by 37 CFR 1.321. 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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4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
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Electronic Acknowledgement Receipt	
EFS ID:	18126794
Application Number:	13744984
International Application Number:	
Confirmation Number:	9610
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:	Jonathan G. Lombardo/Belinda Fields
Filer Authorized By:	Jonathan G. Lombardo
Attorney Docket Number:	I-2-0526US05
Receipt Date:	05-FEB-2014
Filing Date:	18-JAN-2013
Time Stamp:	20:21:57
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		20140205_I_2_0526US05_Reply2.PDF	84172 61ec19a769124c49ca0d1e7ca34da747d1d374da	yes	3

	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Response After Final Action		1	1	
	Applicant Arguments/Remarks Made in an Amendment		2	3	
Warnings:					
Information:					
2	Transmittal Letter	20140205_I_2_0526US05_Request_To_Correct_ADS.PDF	69536 cb8d1455ac7c00494242fe0bc4b6514b172599a4	no	2
Warnings:					
Information:					
3	Application Data Sheet	20140205_I_2_0526US05_Corrected_ADS.PDF	598308 197024a3d4425ec265db41e2d6c2f01533305bbc	no	7
Warnings:					
Information:					
This is not an USPTO supplied ADS fillable form					
4	Assignee showing of ownership per 37 CFR 3.73.	20140205_I_2_0526US05_Statement_Under_3_73c.PDF	124385 410807ae8d5c4470300dfb24c8f543a8ae9b271e	no	3
Warnings:					
Information:					
5	Terminal Disclaimer Filed	20140205_I_2_0526US05_Terminal_Disclaimer.PDF	147765 a5ea73762096d2aa672c0ada66146cece74a514f	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	1024166		

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.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/744,984	01/18/2013	Philip J. Pietraski	I-2-0526US05	9610

24374 7590 12/05/2013

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
12/05/2013	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. 13/744,984	Applicant(s) PIETRASKI ET AL.	
	Examiner FRITZ ALPHONSE	Art Unit 2112	AIA (First Inventor to File) Status No

-- 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 *3* MONTHS 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 *10/12/2013*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

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

3)☐ 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.

4)☐ 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*

5)☒ Claim(s) *1-14* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-14* is/are rejected.

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

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

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ 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).

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).

Certified copies:

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)).

** 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) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

1. The present application is being examined under the pre-AIA first to invent provisions.

DETAILED ACTION

2. This Office Action is in response to the Amendment filed on 10/07/2013. Claims 1-14 are pending.

Terminal Disclaimer

3. The Terminal Disclaimer has been disapproved…

4. The power of attorney has not been accepted because the party who is giving power of attorney has not been identified. Power of attorney may only be signed by the applicant for patent (37 CFR 1.42) or the patent owner. A patent owner who was not the applicant must appoint any power of attorney in compliance with 37 CF.R 3.71 and 3.73. See 37 CFR 1.32(b)(4).

5. Any request to correct or update the name of the applicant must include an application data sheet (ADS) in compliance with 37 CFR 1.76 specifying the correct or updated name of the applicant in the applicant information section. Any request to change the applicant after an original applicant has been specified under 37 CFR 1.46(b) must include a new ADS in compliance with 37 CFR 1.76 specifying the applicant in the applicant information section and comply with 37 CFR 3.71 and 3.73. See 37 CFR 1.46(c).

Double Patenting

6. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the claims at issue are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van*

Ornum, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the reference application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO internet Web site contains terminal disclaimer forms which may be used. Please visit http://www.uspto.gov/forms/. The filing date of the application will determine what form should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to http://www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

7. Claims 1-7, 13-14 and 8-12 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-8 of U.S. Patent No. 8/074,143. Although the claims at issue are not identical, they are not patentably distinct from each other because claims 1-14 of the application are substantially equivalent to claims 1-8 of U.S. Patent No. 8,074,143.

Conclusion

8. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

/FRITZ ALPHONSE/

Primary Examiner, Art Unit 2112

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13744984	PIETRASKI ET AL.
	Examiner	Art Unit
	FRITZ ALPHONSE	2112

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
714	790,774,786,752,755,800	12/2/2013	FA

SEARCH NOTES		
Search Notes	Date	Examiner
East Search	12/2/2013	FA
Plus Search (See East Search)	12/2/2013	FA

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	163	("20020051501" "6088387" "6028897" "6014411" "6044116" "6370669" "6397367" "6622281" "6665833" "6697986" "6744744" "6807238" "6816556" "6829305" "6892342" "6903665" "7016427" "7016658" "7027782" "7072307" "7089480" "7146552" "7165209" "7200792" "7210089" "7251285" "7280609" "7283509" "7293217" "7415263" "7421033" "7458011" "7483389" "7496079" "7523383" "7536624" "7620872" "7640486" "7673213" "7676731" "7676732" "7743312" RE41498 "7782973" "7802164" "7814390" "7814391" "7827466" "7925963" "7958425" "7987414" "8074143" "7925963" "7958425" "7987414" "8074143" "8250429" "8254284" "8275032" "8359520" "8386877" "8416794" "20010009569" "20010010710" "20010034209" "20020015419" "20020027956" "20020166093" "20030007476" "20030021240" "20030031233" "20030076870" "20030097629" "20030120995" "20030135811" "20030171121" "20040125765" "20040139378" "20040146029" "20040184553" "20040187069" "20040187070" "20040257992" "20050053168" "20050100085" "20050100103" "20050172201" "20050172202" "20050204251" "20050216819" "20050283710" "20060031737" "20060150051" "20060179401" "20060190801" "20060206781" "20060239237" "20060251001" "20070089025" "20070101232").pn.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/12/02 10:58
L2	15	(rate matching interleav$4 bit stream buffer$4 virtual buffer)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/12/02 10:59
L3	1	1 2	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	AND	OFF	2013/12/02 10:59

			IBM_TDB			
S1	233	(rate matching interleav$4 bit stream)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/29 11:38
S2	0	(buffer$4 interleav bit stream virtual buffer)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/29 11:40
S3	31	(buffer$4 interleav$4 bit stream virtual buffer)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/29 11:40
S4	19	S1 S3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/05/29 11:40
S5	9124	virtual near4 buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/31 23:09
S6	0	virtual adj buffer is a physical adj buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/31 23:24
S7	92	virtual adj buffer same physical adj buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/31 23:24
S8	14	(rate matching interleav$4 bit stream buffer$4 virtual buffer)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/31 23:45
S9	162	("20020051501" "6088387" "6028897" "6014411" "6044116" "6370669" "6397367" "6622281" "6665833" "6697986" "6744744" "6807238"	US-PGPUB; USPAT; USOCR; FPRS;	OR	OFF	2013/06/01 13:13

		"6816556" "6829305" "6892342" "6903665" "7016427" "7016658" "7027782" "7072307" "7089480" "7146552" "7165209" "7200792" "7210089" "7251285" "7280609" "7283509" "7293217" "7415263" "7421033" "7458011" "7483389" "7496079" "7523383" "7536624" "7620872" "7640486" "7673213" "7676731" "7676732" "7743312" RE41498 "7782973" "7802164" "7814390" "7814391" "7827466" "7925963" "7958425" "7987414" "8074143" "7925963" "7958425" "7987414" "8074143" "8250429" "8254284" "8275032" "8359520" "8386877" "8416794" "20010009569" "20010010710" "20010034209" "20020015419" "20020027956" "20020166093" "20030007476" "20030021240" "20030031233" "20030076870" "20030097629" "20030120995" "20030135811" "20030171121" "20040125765" "20040139378" "20040146029" "20040184553" "20040187069" "20040187070" "20040257992" "20050053168" "20050100085" "20050100103" "20050172201" "20050172202" "20050204251" "20050216819" "20050283710" "20060031737" "20060150051" "20060179401" "20060190801" "20060206781" "20060239237" "20060251001" "20070089025" "20070101232").pn.	EPO; JPO; DERWENT; IBM_TDB			
S10	14	(rate matching interleav$4 bit stream buffer$4 virtual buffer)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/06/01 13:16
S11	92	virtual adj buffer same physical adj buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/06/01 13:17
S12	0	S9 S10 S11	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/01 13:17
S13	76	S9 and rate near4 matching	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/01 13:27

S14	47	S13 and interleav$4 bit near4 stream	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/01 13:27
S15	1	S14 and buffer$4 interleav$4 bit stream	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/06/01 13:29
S16	1	S9 and buffer$4 interleav$4 bit stream	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/06/01 13:50
S17	1	S10 S14	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/01 13:51
S18	0	S9 and S11	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:51
S19	76	S9 and S13	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:51
S20	0	S19 and mate same matching	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:58
S21	76	S19 and rate same matching	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:58
S22	7177	"16" and virtual near4 buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	OR	OFF	2013/06/01 13:58

			DERWENT; IBM_TDB			
S23	11	S21 and virtual near4 buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:58
S24	44	S13 and "714"/$.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 14:11

12/2/2013 11:00:20 AM
C:\Users\falphonse\Documents\EAST\Workspaces\13744984.wsp

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13744984	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	12/02/2013								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
	10	✓								
	11	✓								
	12	✓								

Application Number	Application/Control No.	Applicant(s)/Patent under Reexamination	
	13/744,984	PIETRASKI ET AL.	

Document Code - DISQ	Internal Document – DO NOT MAIL

TERMINAL DISCLAIMER	☐ APPROVED	☒ DISAPPROVED
Date Filed : 07 OCT 2013	**This patent is subject to a Terminal Disclaimer**	

Approved/Disapproved by:

The power of attorney has not been accepted because the party who is giving power of attorney has not been identified. Power of attorney may only be signed by the applicant for patent (37 CFR 1.42) or the patent owner. A patent owner who was not the applicant must appoint any power of attorney in compliance with 37 CF.R 3.71 and 3.73. See 37 CFR 1.32(b)(4).

Any request to correct or update the name of the applicant must include an application data sheet (ADS) in compliance with 37 CFR 1.76 specifying the correct or updated name of the applicant in the applicant information section. Any request to change the applicant after an original applicant has been specified under 37 CFR 1.46(b) must include a new ADS in compliance with 37 CFR 1.76 specifying the applicant in the applicant information section and comply with 37 CFR 3.71 and 3.73. See 37 CFR 1.46(c).

JAB

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/744,984	01/18/2013	Philip J. Pietraski	I-2-0526US05

CONFIRMATION NO. 9610

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

MISCELLANEOUS NOTICE

OC000000064284673

Date Mailed: 10/09/2013

A communication which cannot be delivered in electronic form has been mailed to the applicant.

Doc Code: N572

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PHILADELPHIA, PA 19103

Date Mailed: 10/09/2013

DENIAL OF REQUEST FOR POWER OF ATTORNEY

The request for Power of Attorney filed 10/07/2013 is acknowledged. However, the request cannot be granted at this time for the reason stated below.

- ☐ The Power of Attorney you provided did not comply with the new Power of Attorney rules that became effective on June 25, 2004. See 37 CFR 1.32.
- ☐ The revocation is not signed by the applicant, the assignee of the entire interest, or one particular principal attorney having the authority to revoke.
- ☐ The Power of Attorney is from an assignee and the Certificate required by 37 CFR 3.73(c) has not been received.
- ☐ The person signing for the assignee has omitted their empowerment to sign on behalf of the assignee.
- ☐ The inventor(s) is without authority to appoint attorneys since the assignee has intervened as provided by 37 CFR 3.71.
- ☐ The signature(s) of _____ , a co-inventor in this application, has been omitted. The Power of Attorney will be entered upon receipt of confirmation signed by said co-inventor(s).
- ☐ The person(s) appointed in the Power of Attorney is not registered to practice before the U.S. Patent and Trademark Office.
- ☐ Only one Customer Number can be designated for the Power of Attorney in an application. The Customer Number that was captured is the first Customer Number provided on the Power of Attorney document.
- ☐ A request under 37 CFR 1.48 to add an inventor was granted in this application, however, no power of attorney consistent with the power of attorney granted by the originally named inventive entity has been received. Thus, the addition of the inventor has resulted in the loss of power of attorney in the application. See 37 CFR 1.32(e).
- ☑ The power of attorney has not been accepted because the party who is giving power of attorney has not been identified. Power of attorney may only be signed by the applicant for patent (37 CFR 1.42) or the

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patent owner. A patent owner who was not the applicant must appoint any power of attorney in compliance with 37 CFR 3.71 and 3.73. See 37 CFR 1.32(b)(4).

☐ The power of attorney from the inventors has not been accepted because it is a copy from a prior national application for which benefit is claimed and the continuing application names an inventor who was not named as an inventor in the prior application.

☐ The power of attorney from the inventors has not been accepted because the power of attorney must be signed by the applicant for patent. See 37 CFR 1.32(b)(4).

☑ Any request to correct or update the name of the applicant must include an application data sheet (ADS) in compliance with 37 CFR 1.76 specifying the correct or updated name of the applicant in the applicant information section. Any request to change the applicant after an original applicant has been specified under 37 CFR 1.46(b) must include a new ADS in compliance with 37 CFR 1.76 specifying the applicant in the applicant information section and comply with 37 CFR 3.71 and 3.73. See 37 CFR 1.46(c).

Any inquiries regarding this notice should be directed to the Application Assistance Unit at 571-272-4200.

/NB/

Application Assistance Unit
571-272-4200

PTO/AIA/26 (04-13)
Approved for use through 04/30/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT 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.

TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT	Docket Number (Optional) I-2-0526US05

In re Application of: Pietraski et al.

Application No.: 13/744,984

Filed: January 18, 2013

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

The applicant, InterDigital Technology Corporation, owner of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of **prior patent** No. 8,074,143 as the term of said **prior patent** is presently shortened by any terminal disclaimer. The applicant hereby agrees that any patent so granted on the instant application shall be enforceable only for any during such period that it and the **prior patent** are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the applicant does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term of the **prior patent**, "as the term of said **prior patent** is presently shortened by any terminal disclaimer," in the event that said **prior patent** later:

expires for failure to pay a maintenance fee;
is held unenforceable;
is found invalid by a court of competent jurisdiction;
is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
has all claims canceled by a reexamination certificate;
is reissued; or
is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

Check either box 1 or 2 below, if appropriate.

1. ☐ The undersigned is the applicant. If the applicant is an assignee, the undersigned is authorized to act on behalf of the assignee.

I hereby acknowledge that any willful false statements made are punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

2. ☑ The undersigned is an attorney or agent of record. Reg. No. 56,982

/Wesley T. McMichael/ — Signature
October 7, 2013 — Date

Wesley T. McMichael — Typed or printed name

Attorney — Title
215-568-6400 — Telephone Number

☑ Terminal disclaimer fee under 37 CFR 1.20(d) included.

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.

This collection of information is required by 37 CFR 1.321. 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.**

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

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.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
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.

PTO/SB/22 (03-13)
Approved for use through 3/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)

Docket Number (Optional): I-2-0526US05

Application Number: 13/744,984

Filed: January 18, 2013

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

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	Micro Entity Fee	
☑	One month (37 CFR 1.17(a)(1))	$200	$100	$50	$ 200
☐	Two months (37 CFR 1.17(a)(2))	$600	$300	$150	$
☐	Three months (37 CFR 1.17(a)(3))	$1,400	$700	$350	$
☐	Four months (37 CFR 1.17(a)(4))	$2,200	$1,100	$550	$
☐	Five months (37 CFR 1.17(a)(5))	$3,000	$1,500	$750	$

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

☐ Applicant certifies micro entity status. See 37 CFR 1.29.
Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

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

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

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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. 37 CFR 3.73(b) statement is enclosed (Form PTO/SB/96).

☑ attorney or agent of record. Registration number 56,982.

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

/Wesley T. McMichael/ — Signature

October 7, 2013 — Date

Wesley T. McMichael — Typed or printed name

215-568-6400 — Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.

☑ * Total of one (1) 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.

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.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
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.

PTO/AIA/80 (07-12)
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POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

■ Practitioners associated with Customer Number: 24374

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

■ The address associated with Customer Number: 24374

OR

☐	Firm or Individual Name			
	Address			
	City		State	Zip
	Country			
	Telephone		Email	

Assignee Name and Address: InterDigital Technology Corporation
200 Bellevue Parkway
Suite 300
Wilmington, DE 19809

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	[signature]	Date	17-JAN-2013
Name	Bradley N. Ditty	Telephone	
Title	Senior Patent Executive		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. 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 3 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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STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Pietraski et al.

Application No./Patent No.: 13/744,984 Filed/Issue Date: January 18, 2013

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

InterDigital Technology Corporation, a corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

   ☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☑ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 014684, Frame 0352, or for which a copy thereof is attached.

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____

   The document was recorded in the United States Patent and Trademark Office at

   Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____

   The document was recorded in the United States Patent and Trademark Office at

   Reel _____, Frame _____, or for which a copy thereof is attached.

This collection of information is required by37 CFR3.73(b). The information is required toobtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentialityis governed by35 U.S.C. 122and 37 CFR1.11 and1.14. Thiscollection is estimated to take 12 minutes to complete, including gathering, preparing, and submittingthe 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 tothe 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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STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

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The document was recorded in the United States Patent and Trademark Office at

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5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☐ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Wesley T. McMichael/	October 7, 2013
Signature	Date
Wesley T. McMichael	56,982
Printed or Typed Name	Title or Registration Number

Privacy Act Statement

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

The informationprovided 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.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the informationin order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an InternationalApplication 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, arecord 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 thissystem 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.

Electronic Patent Application Fee Transmittal

Application Number:	13744984
Filing Date:	18-Jan-2013
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:	Wesley T. McMichael/Belinda Fields
Attorney Docket Number:	I-2-0526US05

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	200	200

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Statutory or Terminal Disclaimer	1814	1	160	160
		Total in USD ($)		**360**

Electronic Acknowledgement Receipt	
EFS ID:	17059234
Application Number:	13744984
International Application Number:	
Confirmation Number:	9610
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:	Wesley T. McMichael/Belinda Fields
Filer Authorized By:	Wesley T. McMichael
Attorney Docket Number:	I-2-0526US05
Receipt Date:	07-OCT-2013
Filing Date:	18-JAN-2013
Time Stamp:	17:13:57
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$360
RAM confirmation Number	3708
Deposit Account	090435
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

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Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		20131007_I_2_0526US05_Reply1.PDF	102837 727104bfe13a8128b50bfd289436f4d8c28bc4fe	yes	8

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment/Req. Reconsideration-After Non-Final Reject	1	1
Claims	2	5
Applicant Arguments/Remarks Made in an Amendment	6	8

Warnings:					
Information:					
2	Transmittal Letter	20131007_I_2_0526US05_Fee_Transmittal.PDF	255776 6d8f6dee58e9530a6ec6699f57f65a587be8ad09	no	2
Warnings:					
Information:					
3	Terminal Disclaimer Filed	20131007_I_2_0526US05_Terminal_Disclaimer.PDF	147897 14072e205075b3c98189b8eb7e6c9c563410ef6b	no	2
Warnings:					
Information:					
4	Extension of Time	20131007_I_2_0526US05_Petition_For_Extension.PDF	187246 af8f6312d969ab8266a8d2b240d12f0f4c5fc3aa	no	2
Warnings:					
Information:					
5	Power of Attorney	20131007_I_2_0526US05_POA.PDF	86478 5ed1518773f91b63dae06ef035808c0119cce7ad	no	1
Warnings:					
Information:					
6	Assignee showing of ownership per 37 CFR 3.73.	20131007_I_2_0526US05_Statement_Under_3_73c.PDF	118227 9b2f2d9c5a7fc3062c4d795dad2bf354b05a3f6b	no	3
Warnings:					
Information:					
7	Fee Worksheet (SB06)	fee-info.pdf	32662 2c7be04584f3526f49ea8013a69be22cfd9f8c24	no	2

Warnings:	
Information:	
Total Files Size (in bytes):	931123

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.:	13/744,984
Confirmation No.: 9610	
Filed:	January 18, 2013
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-2-0526US05

Date: **October 7, 2013**

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 and Terminal Disclaimer are being timely filed in response to the Office Action dated June 7, 2013 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:

What is claimed is:

1. (Currently amended) A method of performing rate matching in a wireless communication terminal, the method comprising:

interleaving a first bit stream to produce an interleaved first bit stream;

interleaving a second bit stream to produce an interleaved second bit stream;

interleaving a third bit stream to produce an interleaved third bit stream;

buffering the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream in a virtual buffer; and

performing rate matching on at least one output of the virtual buffer.

2. (Original) The method of claim 1 wherein the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream are buffered on a condition that the number of bits of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream is not larger than a size of the virtual buffer.

3. (Original) The method of claim 2, further comprising:

buffering a portion of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream in the virtual buffer on a condition that the number of bits of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream is larger than a size of the virtual buffer.

4. (Original) The method of claim 3 wherein the buffered portion of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream includes all of the interleaved first bit stream.

5. (Original) The method of claim 1, further comprising:

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

6. (Original) The method of claim 1 performed by a wireless transmit/receive unit (WTRU).

7. (Original) The method of claim 1 performed by a node B.

8. (Original) An apparatus for performing rate matching, the apparatus comprising:

a first interleaver configured to interleave a first bit stream to produce an interleaved first bit stream;

a second interleaver configured to interleave a second bit stream to produce an interleaved second bit stream;

a third interleaver configured to interleave a third bit stream to produce an interleaved third bit stream;

a virtual buffer configured to buffer the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream; and

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

9. (Original) The apparatus of claim 8 wherein the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream are buffered on a condition that the number of bits of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream is not larger than a size of the virtual buffer.

10. (Original) The apparatus of claim 9 wherein the virtual buffer is further configured to buffer a portion of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream on a condition that the number of bits of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream is larger than a size of the virtual buffer.

11. (Original) The apparatus of claim 10 wherein the buffered a portion of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream includes all of the interleaved first bit stream.

12. (Original) The apparatus of claim 8, further comprising:
a bit collection unit configured to collect bits associated with the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream.

13. (Original) The apparatus of claim 7 configured as a wireless transmit/receive unit (WTRU).

14. (Original) The apparatus of claim 7 configured as a node B.

REMARKS/ARGUMENTS

After the foregoing Amendment, claims 1-14 are currently pending in this application. Claim 1 is amended.

Double Patenting Rejection

Claims 1-7, 13-14 and 8-12 are rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-3 and 4-8 of U.S. Patent No. 8,074,143. A Terminal Disclaimer is submitted herewith to overcome the nonstatutory obviousness-type double patenting rejection. The withdrawal of the nonstatutory obviousness-type double patenting rejection is respectfully requested.

Claim Rejections - 35 USC § 101

Claims 1-7, 13-14 are rejected under 35 U.S.C. 101 because the claimed invention is allegedly directed to non-statutory subject matter. The applicants strongly disagree, nevertheless in the interest of advancing prosecution; the claim 1 has been amended to specify that the method is performed, "in a wireless communication terminal". Further, there is sufficient recitation of a machine or transformation in claims 1-7 and 13-14. The rejected claims define a method of

performing rate matching in which data is manipulated or transformed. The method claims define how various data streams are interleaved, buffered and sent to the rate matching circuits as shown in Figures 2 and 10, and described in paragraphs [0005], [0044], and [0045]. Further to that, 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 an output data stream in a wireless transmit/receive unit (WTRU) or Node B. Therefore, the manipulation of the data streams constitutes a transformation of the data satisfying 35 U.S.C. 101 rejection.

Accordingly, withdrawal of the 101 rejection is respectfully requested.

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 /Wesley T. McMichael/
Registration No. 56,982

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

WTM/JDW/bbf
Enclosures

PTO/SB/17 (03-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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FEE TRANSMITTAL

Complete if known	
Application Number	13/744,984
Filing Date	January 18, 2013
First Named Inventor	Pietraski et al.
Examiner Name	Fritz Alphonse
Art Unit	2112
Practitioner Docket No.	I-2-0526US05

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

☐ Applicant certifies micro entity status. See 37 CFR 1.29. Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

TOTAL AMOUNT OF PAYMENT ($) $360

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 Communications, LLC

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 underpayment of fee(s) under 37 CFR 1.16 and 1.17 ☑ Credit any overpayment of fee(s)

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 (U = undiscounted fee; S = small entity fee; M = micro entity fee)

	FILING FEES			SEARCH FEES			EXAMINATION FEES			
Application Type	**U ($)**	**S ($)**	**M ($)**	**U ($)**	**S ($)**	**M ($)**	**U ($)**	**S ($)**	**M ($)**	**Fees Paid ($)**
Utility	280	140*	70	600	300	150	720	360	180	
Design	180	90	45	120	60	30	460	230	115	
Plant	180	90	45	380	190	95	580	290	145	
Reissue	280	140	70	600	300	150	2,160	1,080	540	
Provisional	260	130	65	0	0	0	0	0	0	

* The $140 small entity status filing fee for a utility application is further reduced to $70 for a small entity status applicant who files the application via EFS-Web.

2. EXCESS CLAIM FEES

Fee Description	**Undiscounted Fee ($)**	**Small Entity Fee ($)**	**Micro Entity Fee ($)**
Each claim over 20 (including Reissues)	80	40	20
Each independent claim over 3 (including Reissues)	420	210	105
Multiple dependent claims	780	390	195

Total Claims		**Extra Claims**		**Fee ($)**		**Fee Paid ($)**
_____	-20 or HP =	_____	x	_____	=	_____

HP = highest number of total claims paid for, if greater than 20.

Indep. Claims		**Extra Claims**		**Fee ($)**		**Fee Paid ($)**
_____	-3 or HP =	_____	x	_____	=	_____

HP = highest number of independent claims paid for, if greater than 3.

Multiple Dependent Claims	
Fee ($)	**Fee Paid ($)**
_____	_____

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 $400 ($200 for small entity) ($100 for micro 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 =	_____	/ 50 =	_____ (round **up** to a whole number)	x	_____	=	_____

4. OTHER FEE(S) **Fees Paid ($)**

Non-English specification, $130 fee (no small or micro entity discount) _____

Non-electronic filing fee under 37 CFR 1.16(t) for a utility application, $400 fee ($200 small or micro entity) _____

Other (e.g., late filing surcharge): Terminal Disclaimer and Petition for Extension $360

SUBMITTED BY

Signature	/Wesley T. McMichael/	Registration No. (Attorney/Agent) 56,982	Telephone 215-568-6400
Name (Print/Type)	Wesley T. McMichael		Date October 7, 2013

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.**

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

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.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
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.

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	13744984
	Filing Date	2013-01-18
	First Named Inventor	Pietraski et al.
	Art Unit	2112
	Examiner Name	Fritz Alphonse
	Attorney Docket Number	I-2-0526US05

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] ¡	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	20020004478	KR	A	2002-01-16	LG ELECTRONICS INC	* English abstract provided	☐
	2	0048353	WO	A1	2000-08-17	HUGHES ELECTRONICS CORP	* Corresponds to KR 20010052246	☐

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	13744984
	Filing Date	2013-01-18
	First Named Inventor	Pietraski et al.
	Art Unit	2112
	Examiner Name	Fritz Alphonse
	Attorney Docket Number	I-2-0526US05

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1		☐

If you wish to add additional non-patent literature document citation information please click the Add button Add

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

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

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13744984
	Filing Date	2013-01-18
	First Named Inventor	Pietraski et al.
	Art Unit	2112
	Examiner Name	Fritz Alphonse
	Attorney Docket Number	I-2-0526US05

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Wesley T. McMichael/	Date (YYYY-MM-DD)	2013-07-03
Name/Print	Wesley T. McMichael	Registration Number	56,982

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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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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)).

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1) Family number: 28378322 (KR20020004478A) © PatBase

Title: FLEXIBLE DATA RATE MATCHING METHOD

Priority: KR20000038387 20000705

Family:

Publication number	Publication date	Application number	Application date
KR100672347 B1	20070124	KR20000038387	20000705
KR20020004478 A	20020116	KR20000038387	20000705

Assignee(s):(std): LG ELECTRONICS INC

Inventor(s):(std): KIM GI JUN ; LEE YEONG JO ; YOON YEONG U

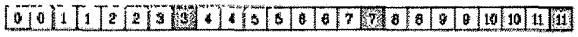
International class (IPC 8-9): H04B1/69 (Advanced/Invention); H04B1/69 (Advanced/Non-invention); H04B1/69 (Core/Invention)

International class (IPC 1-7): H04B1/69

Classification Explorer

Forward Citations: KR101008612,

Abstract:



Source: KR20020004478A PURPOSE: A flexible data rate matching method is provided to support a flexible data rate in the case of using a turbo code on a physical layer. CONSTITUTION: In a process of interleaving a channel-coded encoding sequence to be mapped on a physical layer, the channel-coded encoding sequence is divided into code groups of two types having different bit pattern so that an encoding sequence of a different bit rate channel-coded to the turbo code can have a constant symbol rate, and then each bit in each code group is repetitively interleaved by a different repetitive factor. Thus, the distribution of energy can be made uniform with respect to each of two turbo code constitution encoders, resultantly improving decoding function.

(19) 대한민국특허청(KR)
(12) 공개특허공보(A)

(11) 공개번호 특2002-0004478
(43) 공개일자 2002년01월16일

(51) 국제분류코드
H04B 1/69

(21) 출원번호 10-2000-0038387

(22) 출원일자 2000년07월05일

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(74) 대리인
강용복
김용인

(77) 심사관
없음

전체 청구항 수 : 총 13 항

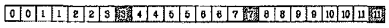
(54)가변 데이터 레이트 매칭 방법

(57)요 약

본 발명은 차세대 이동 통신에 관한 것으로, 특히 물리 계층상에서 터보 코드를 사용하는 경우 가변 데이터 레이트를 지원하기 위한 가변 데이터 레이트 매칭 방법에 관한 것이다. 이와 같은 본 발명에 따른 가변 데이터 레이트 매칭 방법은 채널 코딩된 부호화열이 물리 계층에 매핑되도록 인터리빙하는 과정에서,

상기 터보 코드로 채널 코딩된 다른 비트 레이트의 부호화열이 일정한 심볼 레이트가 되도록, 상기 채널 코딩된 부호화열이 서로 다른 비트 패턴을 갖는 두 가지 타입의 코드 그룹들로 나뉘어, 각 코드 그룹내에서 서로 다른 반복 팩터에 의해 각 비트들이 반복되어 인터리빙된다. 따라서, 에너지의 분포를 두개의 터보 코드 구성 부호화기의 각각에 대하여 균일하게 줄 수 있으며, 이로 인하여 복호 성능을 향상시킬 수 있다

대 표 도 - 도 3



키워드 : 터보 코드, 코드 그룹, 오프셋

This Facsimile Page has been artificially created from KIPO data.

청구의 범위

청구항 1

채널 코딩된 부호화열이 물리 계층에 매핑되도록 인터리빙하는 과정에서,

상기 터보 코드로 채널 코딩된 다른 비트 레이트의 부호화열이 일정한 심볼 레이트가 되도록, 상기 채널 코딩된 부호화열이 서로 다른 비트 패턴을 갖는 두 가지 타입의 코드 그룹들로 나뉘어, 각 코드 그룹내에서 서로 다른 반복 팩터에 의해 각 비트들이 반복되어 인터리빙되는 것을 특징으로 하는 가변 데이터 레이트 매칭 방법.

청구항 2

제 1항에 있어서, 상기 임의의 N개 코드 그룹들은 상기 채널 코딩된 부호화열의 입력 비트열의 길이로 정해지는 것을 특징으로 하는 가변 데이터 레이트 매칭 방법.

청구항 3

제 1항에 있어서, 상기 전체 코드 그룹 중에서 상기 제2 타입의 코드 그룹이 될 개수는 원하는 인터리버 길이를 상기 채널 코딩된 부호화열의 입력 비트열의 길이로 나눈 나머지 값으로 정해지는 것을 특징으로 하는 가변 데이터 레이트 매칭 방법.

청구항 4

제 1항에 있어서, 상기 두 가지 타입의 코드 그룹 중의 하나인 제1 타입 코드 그룹에 할당된 전체 비트수는 원하는 인터리버의 길이를 채널 코딩된 부호화열
의 입력 비트열 길이로 나눠준 값을 넘지 않는 최대의 정수로 정해지는 것을 특징으로 하는 가변 데이터 레이트 매칭 방법.

청구항 5

제 4항에 있어서, 상기 제1 타입 코드 그룹에서 상기 제2 반복 팩터를 가져야 하는 비트들의 개수는 상기 제1 타입 코드 그룹에 할당된 비트열의 길이를 상기 채널 코딩 레이트의 역수로 나눠준 나머지 값으로 정해지는 것을 특징으로 하는 가변 데이터 레이트 매칭 방법.

청구항 6

제 1항에 있어서, 두 가지 타입의 코드 그룹 중의 또 다른 하나인 제2 타입 코드 그룹에 해당하는 전체 비트수는 원하는 인터리버의 길이를 상기 채널 코딩된 부호화열의 입력 비트열 길이로 나눠준 값보다 크거나 같은 최소의 정수로 정해지는 것을 특징으로 하는 가변 데이터 레이트 매칭 방법.

청구항 7

제 6항에 있어서, 상기 제2 타입 코드 그룹에서 상기 제2 반복 팩터를 가져야 하는 비트들의 개수는 상기 제1 타입 코드 그룹에서 상기 제2 반복 팩터를 가져야 하는 비트들의 개수보다 1비트 큰 것을 특징으로 하는 가변 데이터 레이트 매칭 방법.

청구항 8

제 1항에 있어서, 상기 각 코드 그룹에서 비트 반복될 양은 코드 그룹간 최대 1비트의 차이가 나는 것을 특징으로 하는 가변 데이터 레이트 매칭 방법.

청구항 9

제 1항에 있어서, 상기 각 코드 그룹내에서 상기 제2 반복 팩터를 사용하게될 비트의 위치를 정하기 위해서, 0부터 (채널 코딩된 부호화열의 입력 비트열의 길이-1)까지 증가하는 코드 그룹 인덱스 i에 대하여 (i-1)번째 코드 그룹까지 상기 제2 반복 팩터를 가지는 코드 비트들의 개수가 "(i*제1 타입 코드 그룹내에서 제2 반복 팩터를 갖는 비트 개수)"와 "(i*채널 코딩된 부호화열에 대한 제2 타입 코드 그룹의 개수)를 (채널 코딩된 부호화열의 입력 비트열의 길이)로 나눈 값보다 크지 않은 최대 정수"의 합에 의하여 산출되는 오프셋을 이용하는 것을 특징으로 하는 가변 데이터 레이트 매칭 방법.

청구항 10

제 1항에 있어서, 상기 채널 코딩된 부호화열에 대하여 상기 제2 반복 팩터를 가지는 비트들이 균일하게 분포되도록 전체 코드 그룹들에 대하여 상기 제2 타입 코드 그룹 개수마다 테스트를 수행하여,

상기 제2 타입 코드 그룹 개수의 정수배를 상기 채널 코딩 부호화열의 입력 비트열로 나눈 나머지가 상기 제2 코드 그룹 개수보다 작은 경우에 제2 타입 코드 그룹을 선택하여 해당 코드 그룹 위치에서 서로 다른 반복 팩터로 비트 반복을 수행하는 것을 특징으로 하는 가변 데이터 레이트 매칭 방법.

청구항 11

제 1항에 있어서, 상기 채널 코딩된 부호화열에 대하여 상기 제2 반복 팩터를 가지는 비트들이 균일하게 분포되도록 전체 코드 그룹들에 대하여 상기 제2 타
입 코드 그룹 개수마다 테스트를 수행하여,

상기 제2 타입 코드 그룹 개수의 정수배를 상기 채널 코딩 부호화열의 입력 비트열로 나눈 나머지가 상기 제2 코드 그룹 개수보다 크거나 같은 경우에 제1 타입 코드 그룹을 선택하여 해당 코드 그룹 위치에서 서로 다른 반폭 팩터로 비트 반복을 수행하는 것을 특징으로 하는 가변 데이터 레이트 매칭 방법.

청구항 12

제 1항에 있어서, 상기 채널 코딩된 데이터들 중에서 시스테메틱 비트열에 대하여 우선적으로 상기 제2 반복 팩터로 비트 반복을 수행하기 위하여, 0부터 (채널 코딩 부호화열의 입력 비트열의 길이-1)까지 증가하는 코드 그룹 인덱스 i에 대하여 (i-1)번째 코드 그룹까지 상기 제2 반복 팩터를 가지는 코드 비트들의 개수가 "i*제1 타입 코드 그룹에서 제2 반복 백터를 갖는 비트개수-1"과 "(i*채널 코딩 부호화열에 대한 제2 타입 코드 그룹의 개수)를 채널 코딩 부호화열의 입력 비트열로 나눈 나머지"와의 합으로 산출되는 오프셋을 이용하는 것을 특징으로 하는 가변 데이터 레이트 매칭 방법.

청구항 13

제 12항에 있어서, 상기 오프셋을 이용하여 상기 채널 코딩 부호화열에 대한 제2 타입 코드 그룹의 개수마다 테스트를 수행하여,

상기 채널 코딩 부호화열에 대한 제2 타입 그룹 개수의 정수배값을 상기 채널 코딩 부호화열의 입력 비트열로 나눈 나머지가 상기 채널 코딩 부호화열에 대한 제2 타입 그룹 개수보다 크거나 같고, 상기 제1 타입 코드 그룹내에서 상기 제2 반
복 팩터에 의한 비트 반복수가 0인 경우에, 상기 제1 반복 팩터에 의해 해당 비트에서 비트 반복을 수행하는 것을 특징으로 하는 가변 데이터 레이트 매칭 방법.

명세서

발명의 명칭

가변 데이터 레이트 매칭 방법{Flexible data rate Matching Method in 3GPP2}

도면의 간단한 설명

[0001] 도 1은 일반적인 터보 코드 방식을 위한 부호화기의 블록 구성도.

[0002] 도 2는 종래 기술에 따른 가변 데이터 레이트 매칭 방법을 나타낸 도면.

[0003] 도 3은 종래 기술에 따른 1/4 레이트 터보 부호를 사용하는 경우 가변 데이터 레이트 매칭의 문제점을 나타낸 도면.

[0004] 도 4는 코드 그룹을 나누지 않았을 경우의 반복 패턴을 나타낸 도면.

[0005] 도 5은 본 발명에 따라 코드 그룹을 나누어 주었을 경우에 대한 반복 패턴을 나타낸 도면.

발명의 상세한 설명

[0006] 본 발명은 차세대 이동 통신에 관한 것으로, 특히 물리 계층상에서 터보 코드를 사용하는 경우 가변 데이터 레이트를 지원하기 위한 가변 데이터 레이트 매칭 방법에 관한 것이다.

[0007] 차세대 이동 통신(3GPP2)에서 채널 코딩된 데이터들이 물리 계층에 매핑되도록 하기 위해서는 시스템에서 원하는 데이터 레이트로 조정할 필요가 있다.

[0008] 이를 위해서 시스템에서는 고정 데이터 레이트 및 가변 데이터 레이트 방식을 지원하는데, 특히 데이터 전송 모드 중에서 가변 데이터 레이트 방식은 차세대 이동 통신(3GPP2)의 각각의 무선 구조상에서 지원하고 있는 표준의 전송율 이외에도 임의의 전송율을 지원할 수 있도록 하는 전송 방법이다.

[0009] 특히, 차세대 이동 통신(3GPP2)의 19.2kbps 이상의 전송율에서는 보조 채널(Supplemental Channel)을 통하여 터보 코드를 채널 부호화 방법으로 지원할 수 있도록 규정하고 있다.

[0010] 이러한 터보 코드는 도 1에서와 같이 두 개의 중첩 시스터메틱 컨벌루션(Recursive Systematic Convolutional;이하 RSC라 약칭함)(10,11) 부호화기와 랜덤한 특성을 가지는 인터리버(12)를 통하여 상기 두 개의 구성 부호화기를 병렬로 연결시켜 구성된다.

[0011] 현재 차세대 이동 통신(3GPP2)상에서 규정하고 있는 터보 코드의 구성 RSC 부호화기(10,11)는 코딩율이 1/3인 RSC 부호화기이고, 궤환 성분에 대한 폴리노미얼(polynomial)은 8진수로 '13'을 사용하고 패리티를 위한 폴리노미얼은 '15'와,'17'을 사용하고 있다.

[0012] 그리고 터보 부호화기의 인터리버(12)로는 선형 합동 시퀀스(Linear Congruential Sequence) 방식을 사용한 인터리버를 사용하고 있다.

[0013] 그러므로, 종래 기술에서는 1/3 레이트의 구성 부호화기를 병렬 연결한 구조를 가지므로, 기본적인 터보 부호화기의 출력 레이트는 1/6 레이트를 가진다.

[0014] 그러나, 실제로 차세대 통신 시스템(3GPP2)의 각각의 무선 구조상에서 가질

수 있는 부호화기의 코드율은 1/2, 1/3, 1/4이며, 이를 지원할 수 있도록 하는 펑쳐링 패턴이 필요하게 된다.

[0015] 따라서, 종래에는 다음 표 1과 표 2에 의한 펑쳐링 패턴을 가지고, 데이터 또는 테일에 대한 비트 펑쳐링을 수행한다.

[0016]

	레이트 1/2	레이트 1/3	레이트 1/4
X_k	1111	1111	1111
Y_k	1010	1111	1111
Z_k	0000	0000	1010
X_k'	0000	0000	0000
Y_k'	0101	1111	0101
Z_k'	0000	0000	1111

[0017]

	레이트 1/2	레이트 1/3	레이트 1/4
X_k	1111	1111	1111
Y_k	1111	1111	1111
Z_k	0000	1111	1111

[0018] 현재 가변 데이터 레이트를 지원하기 위한 펑쳐링 기법은 심볼 반복과 균일 펑쳐링을 결합하여 이루어지는데, 우선적으로 심볼을 일정 팩터만큼 반복하여 우리가 사용하고자 하는 채널 인터리버의 크기보다 큰 수로 만들어준 후 이 중에서 채널 인터리버의 크기보다 큰 부분을 펑쳐링을 통하여 제거하는 방법을 사용하는 것이다.

[0019] 그러나 종래 기술에 따른 심볼 반복과 펑쳐링 기법을 터보 코드에 적용하는 경우에는 문제가 발생할 수 있다.

[0020] 즉, 터보 코드에 대한 복호기는 두 개의 최대 사후(Maximum A Posteriori) 복호기를 인터리버와 디인터리버를 통하여 직렬로 연결한 후, 반복 복호 과정을 통
하여 수행하게 되는데, 이때 복호 후의 성능을 가장 좋게 만들기 위해서는 도 1 각각의 구성 부호화기의 부호화 성능을 동일하도록 만들어 주어야 한다.

[0021] 즉, 수신단의 두 개의 복호기의 성능이 균형이 이루어지기 위해서는 상기 두 개의 복호기로 들어가는 송신단의 각각의 구성 부호화기(10,11)의 출력 패리티 부호화열에 균일한 에너지가 실려 전송됨으로써 가능하다.

[0022] 또한 각각의 복호기의 에너지 분포가 트렐리스 상에서 균일한 분포를 가져야만 복호기의 전체 성능이 최적이 될 것으로 예측할 수 있다.

[0023] 예를 들어, 도 3에 도시된 바와 같이, 모든 펑처링이 두번째 구성(constituent) 부호화기의 마지막 패리티 비트에만 몰려서 발생하고 있으며, 이는 결과적으로 두번째 복호기의 복호성능을 저하시키는 문제점을 가지게 된다.

[0024] 따라서 전체적인 복호 성능에 있어서 나쁜 영향을 줄 것으로 판단할 수 있다.

[0025] 따라서, 본 발명의 목적은 이상에서 언급한 종래 기술의 문제점을 감안하여 안출한 것으로서, 터보 코드를 위한 가변 데이터 레이트 매칭 방법을 제공하기 위한 것이다.

[0026] 본 발명의 다른 목적은 터보 코드를 위한 가변 데이터 레이트를 지원하기 위하여 수행된 심볼 반복과 펑쳐링 기법이 하나의 균일 심볼 반복에 의해 수행되도록 하는 가변 데이터 레이트 매칭 방법을 제공하기 위한 것이다.

[0027] 이상과 같은 목적을 달성하기 위한 본 발명의 일 특징에 따르면, 채널 코딩 된 부호화열이 물리 계층에 매핑되도록 인터리빙하는 과정에서,

[0028] 상기 터보 코드로 채널 코딩된 다른 비트 레이트의 부호화열이 일정한 심볼 레이트가 되도록, 상기 채널 코딩된 부호화열이 서로 다른 비트 패턴을 갖는 두 가지 타입의 코드 그룹들로 나뉘어, 각 코드 그룹내에서 서로 다른 반복 팩터에 의해 각 비트들이 반복되어 인터리빙되는 것을 특징으로 한다.

[0029] 바람직하게, 상기 임의의 N개 코드 그룹들은 상기 채널 코딩된 부호화열의 입력 비트열의 길이로 정해진다.

[0030] 상기 전체 코드 그룹 중에서 상기 제2 타입의 코드 그룹이 될 개수는 원하는 인터리버 길이를 상기 채널 코딩된 부호화열의 입력 비트열의 길이로 나눈 나머지 값으로 정해진다.

[0031] 상기 두 가지 타입의 코드 그룹 중의 하나인 제1 타입 코드 그룹에 할당된 전체 비트수는 원하는 인터리버의 길이를 채널 코딩된 부호화열의 입력 비트열 길이로 나눠준 값을 넘지 않는 최대의 정수로 정해지고, 다른 하나인 제2 타입 코드 그룹에 해당하는 전체 비트수는 원하는 인터리버의 길이를 상기 채널 코딩된 부호화열의 입력 비트열 길이로 나눠준 값보다 크거나 같은 최소의 정수로 정해진다.

[0032] 상기 각 코드 그룹에서 비트 반복될 양은 코드 그룹간 최대 1비트의 차이가 난다.

[0033] 상기 제1 타입 코드 그룹에서 상기 제2 반복 팩터를 가져야 하는 비트들의 개수는 상기 제1 타입 코드 그룹에 할당된 비트열의 길이를 상기 채널 코딩 레이트의 역수로 나눠준 나머지 값으로 정해지며, 상기 제2 타입 코드 그룹에서 상기 제2
반복 팩터를 가져야 하는 비트들의 개수는 상기 제1 타입 코드 그룹에서 상기 제2 반복 팩터를 가져야 하는 비트들의 개수보다 1비트 크게 되도록 한다.

[0034] 상기 각 코드 그룹내에서 상기 제2 반복 팩터를 사용하게될 비트의 위치를 정하기 위해서는, 0부터 (채널 코딩된 부호화열의 입력 비트열의 길이-1)까지 증가하는 코드 그룹 인덱스 i에 대하여 (i-1)번째 코드 그룹까지 상기 제2 반복 팩터를 가지는 코드 비트들의 개수가 "(i*제1 타입 코드 그룹내에서 제2 반복 팩터를 갖는 비트 개수)"와 "(i*채널 코딩된 부호화열에 대한 제2 타입 코드 그룹의 개수)를 (채널 코딩된 부호화열의 입력 비트열의 길이)로 나눈 값보다 크지 않은 최대 정수"의 합에 의하여 산출되는 오프셋을 이용한다.

[0035] 상기 채널 코딩된 부호화열에 대하여 상기 제2 반복 팩터를 가지는 비트들이 균일하게 분포되도록 전체 코드 그룹들에 대하여 상기 제2 타입 코드 그룹 개수마다 테스트를 수행하여, 상기 제2 타입 코드 그룹 개수의 정수배를 상기 채널 코딩 부호화열의 입력 비트열로 나눈 나머지가 상기 제2 코드 그룹 개수보다 작은 경우에 제2 타입 코드 그룹을 선택하여 해당 코드 그룹 위치에서 서로 다른 반복 팩터로 비트 반복을 수행하며, 그 나머지가 크거나 같은 경우에는 제1 타입 코드 그룹을 선택하여 해당 코드 그룹 위치에서 서로 다른 반폭 팩터로 비트 반복을 수행한다.

[0036] 상기 채널 코딩된 데이터들 중에서 시스테메틱 비트열에 대하여 우선적으로 상기 제2 반복 팩터로 비트 반복을 수행하기 위하여, 0부터 (채널 코딩 부호화열의 입력 비트열의 길이-1)까지 증가하는 코드 그룹 인덱스 i에 대하여 (i-1)번째 코드

그룹까지 상기 제2 반복 팩터를 가지는 코드 비트들의 개수가 "i*제1 타입 코드 그룹에서 제2 반복 백터를 갖는 비트개수-1"과 "(i*채널 코딩 부호화열에 대한 제2 타입 코드 그룹의 개수)를 채널 코딩 부호화열의 입력 비트열로 나눈 나머지"와의 합으로 산출되는 오프셋을 이용한다.

[0037] 상기 오프셋을 이용하여 상기 채널 코딩 부호화열에 대한 제2 타입 코드 그룹의 개수마다 테스트를 수행하여, 상기 채널 코딩 부호화열에 대한 제2 타입 그룹 개수의 정수배값을 상기 채널 코딩 부호화열의 입력 비트열로 나눈 나머지가 상기 채널 코딩 부호화열에 대한 제2 타입 그룹 개수보다 크거나 같고, 상기 제1 타입 코드 그룹내에서 상기 제2 반복 팩터에 의한 비트 반복수가 0인 경우에, 상기 제1 반복 팩터에 의해 해당 비트에서 비트 반복을 수행한다.

[0038] 이하 본 발명의 바람직한 일 실시 예에 따른 구성 및 작용을 첨부된 도면을 참조하여 설명한다.

[0039] 본 발명에서는 터보 코드를 이용한 채널 코딩된 부호화열의 가변 데이터 레이트(flexible data rate) 방식을 지원하기 위한 레이트 매칭 과정의 설계에 있어서 우선적으로 심볼 반복과 펑쳐링으로 이루어지는 두 단계의 레이트 매칭 과정을 사용하는 것이 아니라 한 단계의 균일 반복(uniform repetition)을 통하여 레이트 매칭을 수행하여 원하는 인터리버의 길이를 맞추는 방법을 사용한다.

[0040] 그러기 위해서 본 발명에서는 먼저 코드 그룹을 정의한다.

[0041] 본 발명에서 정의된 코드 그룹은 하나의 정보 비트 입력에 대한 채널 부호화기의 출력 비트들의 그룹으로 정의한다.

[0042] 즉, 1/4 레이트(rate)의 부호화기를 예로 들 경우, 하나의 코드 그룹은 4개의 코드 비트들로 구성된다.

[0043] 예를 들어, 하나의 정보 비트 입력에 대한 채널 부호화기의 출력이 표 1의 펑처링 패턴에 의해 1/4 레이트(rate)의 코드 부호화열들이 "x, y, z, z', x, y, y',z'와 같은 형태가 되는 경우, 본 발명에서 정의되는 코드 그룹은 이를 4개씩 묶은 것으로 표현된다.

[0044] 결과적으로, 전체의 데이터 부호화열의 길이를 L이라고 정의하면, 코드 그룹의 개수는 (L/n)으로 정의되고, 이 코드 그룹의 개수는 채널 부호화기의 입력 비트열(I)의 길이가 된다.

[0045] 그리고, 이러한 코드 그룹을 이용하여 전체의 부호화열의 코드 비트들 가운데에서 하나의 폴리노미얼(polynomial)로부터 출력된 부호화열에만 집중적으로 반복이 들어가는 것을 막아주기 위하여 코드에 대한 그룹 단위로 서로 다른 반복 팩터를 가지고 비트 반복이 이루어지도록 한다.

[0046] 따라서, 본 발명에서는 다음 수학식 1과 수학식 2와 같이 서로 다른 반복 팩터 M_1과 M_2를 다음과 같이 정의한다.

[0047] 이하에서 I는 순환 중첩 코드(CRC)와 테일(tail)을 포함하는 채널 부호화기의 입력열의 길이이고, L은 부호화기의 출력열의 길이이다. n은 코딩 레이트의 역수의 값이며, N은 원하는 인터리버 사이즈의 깊이이다.

[0048] 본 발명에서는 심볼 반복이 다음 수학식 1과 수학식 2에 의하여 서로 다른 심볼 팩터를 가지고 각 비트의 반복 수행이 이루어진다.

[0049] 수학식1

$$M = \lfloor \frac{N}{L} \rfloor$$

[0050] 여기에서 $\lfloor x \rfloor$ 는 x를 넘지 않는 최대 정수값이다.

[0051] 수학식2

$$M = \lceil \frac{N}{L} \rceil$$

[0052] 여기에서 LCEIL{ x}RCEIL 는 x보다 크거나 같은 최소 정수값이다.

[0053] 상기 부호화기의 전체 출력열에 대한 서로 다른 비트 패턴으로 출력되는 코드 그룹을 제1 타입과, 제2 타입으로 나누어 상기 제1 타입에 할당된 비트의 전체 개수는 다음 수학식 3에 의해서 산출된다.

[0054] 수학식3

$$R = \lfloor \frac{N}{I} \rfloor$$

[0055] 그리고, 상기 제2 타입에 할당된 비트의 전체 개수는 다음 수학식 4에 의해서 산출된다.

[0056] 수학식4

$$R = \lceil \frac{N}{I} \rceil$$

[0057] 이때, 상기 전체 출력열에 대하여 제1 타입과 제2 타입의 코드 그룹이 균일하게 배치되도록 하기 위하여 먼저 전체의 코드 그룹의 개수 중에서 제2 타입 코드 그룹이 될 개수를 다음 수학식 5에 의하여 산출한다.

[0058] 수학식 5 :

$$K = N \bmod I$$

[0059] 상기 수학식 5에서 전체 코드 그룹중에서 제2 타입 코드 그룹이 될 개수는 인터리버 사이즈 N을 채널 부호화기 입력열의 길이 I로 나눈 나머지를 갖는다.

[0060] 그리고, 본 발명에서는 다음 수학식 6을 이용하여 N개의 비트로 구성된 제1 타입의 코드 그룹내에서 M_2의 반복 팩터를 가지는 비트의 개수를 계산하고, 마찬가지로 제2 타입 코드 그룹내에서 M_2의 반복 팩터를 가지는 비트의 개수를 다음 수학식 7과 같이 정의한다.

[0061] 수학식 6 :

$$K = R \bmod n$$

[0062] 수학식 7 :

$$K = K + 1$$

[0063] 다음으로 i번째 코드 그룹에서 사용하게 될 오프셋 값을 다음 수학식 8의 식으로 정의한다.

[0064] 수학식8

$$O_i = i \times K_{1,GR1} + \lfloor \frac{i \times K_{1,R2}}{I} \rfloor$$

[0065] 즉, 수학식 8은 i번 코드 그룹에서의 테스트를 수행할 경우에 (i-1)번째 그룹까지의 테스트를 수행한 결과인 M_2의 반복 팩터를 가지는 코드 비트들의 개수인 오프셋(offset) 값을 이용하여, 다음과 같은 알고리즘을 통하여 전체 채널 코딩된 부호화열에 대하여 균일한 비트 반복 과정을 수행하게 된다.

[0066] for(i=0;i<I;i++){

[0067] $O_i = i \times K_{1,GR1} + \lfloor \frac{i \times K_{1,R2}}{I} \rfloor$

[0068] if(((i+1)$K_{1,R2}$)mod I<$k_{1,R2}$) {

[0069] for(j=0;j<n ;j++){

[0070] if((7j+O_i)mod n<$K_{1,GR2}$)

[0071] repeat(n*i+j)th bit with repetition factor M_2 else repeat (n*i+j)th bit with repetition factor M_1

[0072] }

[0073] } 제2 타입 코드 그룹의 선택

[0074] else{

[0075] for(j=0;j<n;j++){

[0076] if((7j+O_i)mod n<$K_{1,GR1}$)

[0077] repeat(n*i+j)th bit with repetition factor M_2

[0078] else repeat (n*i+j)th bit with repetition factor M_1

[0079] } 제 1타입 코드 그룹의 선택

[0080] }

[0081] 상기 알고리즘에서는 채널 코딩된 부호화열에 대하여 상기 제2 반복 팩터를 가지는 비트들이 균일하게 분포되도록 전체 코드 그룹들에 대하여 상기 제2 타입 코드 그룹 개수마다 테스트를 수행하여, 상기 제2 타입 코드 그룹 개수의 정수배를 상기 채널 코딩 부호화열의 입력 비트열로 나눈 나머지가 상기 제2 코드 그룹 개수보다 작은 경우에 제2 타입 코드 그룹을 선택하여 해당 코드 그룹 위치에서 서로 다른 반폭 팩터로 비트 반복을 수행하도록 한다.

[0082] 그리고, 상기 선택된 제2 타입 코드 그룹에 할당된 n개의 비트에서 각 비트의 인덱스가 0부터 n까지 증가하는 인덱스 j에 대해 (7j+오프셋)을 n으로 나눈 나머지가 상기 제2 타입 코드 그룹에서 상기 제2 반복 팩터를 갖는 비트의 개수보다 작은 경우에는 상기 제2 반복 팩터에 의해 해당 비트의 반복을 수행하도록 하고, 상기 (7j+오프셋)을 n으로 나눈 나머지가 상기 제2 타입 코드 그룹에서 상기 제2 반복 팩터를 갖는 비트의 개수보다 크거나 같은 경우에는 상기 제1 반복 팩터에 의해 해당 비트의 반복을 수행하하도록 하는 방식을 사용하였다.

[0083] 한편, 상기 제2 타입 코드 그룹 개수의 정수배를 상기 채널 코딩 부호화열의 입력 비트열로 나눈 나머지가 상기 제2 코드 그룹 개수보다 크거나 같은 경우에 제1 타입 코드 그룹을 선택하도록 한다.

[0084] 그리고, 상기 인덱스 j에 대해 (7j+오프셋)을 n으로 나눈 나머지가 상기 제1 타입 코드 그룹에서 상기 제2 반복 팩터를 갖는 비트의 개수보다 작은 경우에는 상기 제2 반복 팩터에 의해 해당 비트의 반복을 수행하고, 상기 (7j+오프셋)을 n으로 나눈 나머지가 상기 제1 타입 코드 그룹에서 상기 제2 반복 팩터를 갖는 비트의 개수보다 크거나 같은 경우에는 상기 제1 반복 팩터에 의해 해당 비트의 반복이 이루어지도록 하는 방식을 이용하였다.

[0085] 예를 들어서 L=20, n=4, I=5인 경우을 생각해 보자. 그리고 이때 원하는 인터리버의 길이가 N=45라고 하자. 그러면 M_1= 2, M_2=3으로 계산된다.

[0086] 이때, 코드 그룹을 나누지 않고 균일한 반복 알고리즘을 사용하게 되면 다음의 도 4와 같은 형태의 반복 패턴을 얻을 수 있다.

[0087] 도 4에서 음영으로 칠해져 있는 부분은 M_2=3의 반복 팩터를 가지는 비트의 위치를 나타내고, 나머지 부분들은 M_1=2의 반복 팩터를 가지는 비트들의 위치를 나타낸다.

[0088] 도 4에서 알 수 있듯이 M_2=3 반복이 들어가는 비트들의 위치가 y 비트열에 집중되고 있으며, 이러한 반복 패턴은 에너지 분포의 균일함에 있어서 좋지 않은 영향을 끼친다고 생각할 수 있다.

[0089] 이때, 만일 본 발명에서 고안된 코드 그룹 단위의 균일 반복 알고리듬을 사용하게 되면 다음의 도 5와 같은 반복 패턴을 얻을 수 있게 된다.

[0090] 도 5를 통하여 알 수 있는 바와 같이 M_2=3의 j에 7을 곱한 이유를 설명하면 다음과 같다.

[0091] 현재 무선 구조별로 지원하는 코드 율은 1/2, 1/3, 1/4의 3가지 종류이다. 이때, 1/4레이트의 터보 부호를 생각하면 j=0에서 3까지의 값을 가지게 된다. 이때 만일 7이 곱해지지 않는 상황을 가정하자.

[0092] 그리고, 하나의 그룹당 K_1값이 2라고 가정하자. 그러면 각각의 코드 비트 그룹에서 선택되는 비트의 위치는 (0,1), (2,3), (0,1), (2,3)을 반복하게 되며, 이 또한 에너지 분포의 불균형을 초래하는 패턴으로 생각할 수 있다. 따라서 만일 7을 곱하여 주고, 생각하게 되면, (0,3), (1,2), (0,3), (1,2)의 패턴을 반복하게 될 것이며, 이에 따라 보다 균일한 형태의 반복 패턴을 얻는 것이 가능하다는 것을 알 수 있다.

[0093] 만일 1/4 코드율의 부호만을 생각한다면, 가장 바람직한 방법은 비트 인덱스 j에 7을 곱하는 것이 아니라 비트 인덱스 j에 대한 비트-리버싱 오퍼레이션(bit-reversing operation)을 정의하는 방법으로 생각할 수 있다.

[0094] 즉, 1/4 레이트의 부호일 경우 (0,1,2,3)의 인덱스를 (0,2,3,1)로 바꾸어 테스트를 수행하는 것이 가장 바람직한 방법이다. 그러나 1/3 레이트의 부호에서는 이러한 방법을 적용할 수 없으므로, 5보다 큰 가장 작은 소수인 7을 곱하여 균일성
을 주고자 했다.

[0095] 상기 알고리즘은 각각의 코드 비트들에 대한 중요도를 고려하지 않은 알고리즘으로 생각할 수 있다.

[0096] 그러므로, 터보 코드의 성능을 최대로 끌어올리기 위해서는 반복 과정에서, 다른 비트보다 큰 반복 팩터를 가지는 위치를 배분하는데 있어서, 시스터메틱(systematic) 비트 성분에 일종의 우선 순위를 두는 것이 바람직하다. 이를 위해서는 앞에서 설명했던 알고리즘을 다음과 같이 또 다른 방식으로 제안한다.

[0097] for(i=0;i<I;i++){

[0098] if({((i+1)×$K_{1,R2}$)mod I≥$K_{1,R2}$}&&{$K_{1,GR1}$=0}) repeat ni^{th} bit with factor M_1 ; 시스테메틱 비트에 대해 우선적으로 반복 팩터 M_2 에 의해 비트 반복

[0099] else ni^{th} bit with repetition factor M_2

[0100] $$0_i = i \times (K_{1,GR1}-1) + \left\lfloor \frac{i \times K_{1,R2}}{I} \right\rfloor$$

[0101] for(j=0;j<n ;j++){

[0102] if({((i+1)×$K_{1,R2}$)mod I<$K_{1,R2}$}&&{(j+|O_i|) mod (n-1)≤$K_{1,GR1}$-1})||

[0103] ({((i+1)×$K_{1,R2}$)mod I≥$K_{1,R2}$}&&{(j+|O_i|) mod (n-1)< $K_{1,GR1}$-1})

[0104] repeat(n×i+j)th bit with repetition factor M_2 otherwise repeat (n×i+j)th bit with repetition factor M_1

[0105] } ; 시스테메틱 비트를 나머지 비트에 대한 반복 팩터 M_1 또는 M_2에 의한 비트 반복이 균등하게 이루어짐

[0106] }

[0107] 위의 알고리즘에서 사용한 방법은 각각의 코드 그룹별로 M_2의 반복 팩터를 가져야 하는 위치를 정할 때에 있어서, 우선적으로, 시스테메틱(systematic) 비트 위치에 M_2의 반복 팩터를 할당하고, 나머지의 코드 그룹의 비트들에 대하여 균등한 방식으로 반복 팩터를 할당하는 방법이다.

[0108] 이와 같은 원리를 적용하기 위해서는 0부터 (채널 코딩 부호화열의 입력 비트열의 길이-1)까지 증가하는 코드 그룹 인덱스 i에 대하여 (i-1)번째 코드 그룹까지 상기 제2 반복 팩터를 가지는 코드 비트들의 개수가 "i*제1 타입 코드 그룹에서 제2 반복 백터를 갖는 비트개수-1"과 "(i*채널

코딩 부호화열에 대한 제2 타입 코드 그룹의 개수)를 채널 코딩 부호화열의 입력 비트열로 나눈 나머지"와의 합으로 산출되는 오프셋을 이용한다.

[0109] 이러한 오프셋을 이용하여 상기 알고리즘에서는 상기 채널 코딩 부호화열에 대하여 테스트를 수행한다.

[0110] 따라서, 상기 채널 코딩 부호화열에 대한 제2 타입 그룹 개수의 정수배값을 상기 채널 코딩 부호화열의 입력 비트열로 나눈 나머지가 상기 채널 코딩 부호화열에 대한 제2 타입 그룹 개수보다 크거나 같고, 상기 제1 타입 코드 그룹내에서 상기 제2 반복 팩터에 의한 비트 반복수가 0인 경우에, 상기 제1 반복 팩터에 의해 해당 비트에서 비트 반복을 수행하도록 한다.

[0111] 또는 상기 채널 코딩 부호화열에 대한 제2 타입 그룹 개수의 정수배값을 상기 채널 코딩 부호화열의 입력 비트열로 나눈 나머지가 상기 채널 코딩 부호화열에 대한 제2 타입 그룹 개수보다 작거나, 상기 제1 타입 코드 그룹내에서 상기 제2 반복 팩터에 의한 비트 반복수가 0이 아닌 경우에, 상기 제2 반복 팩터에 의해 현 코드 그룹내의 시스테메틱 비트에 대해 비트 반복을 수행하도록 한다.

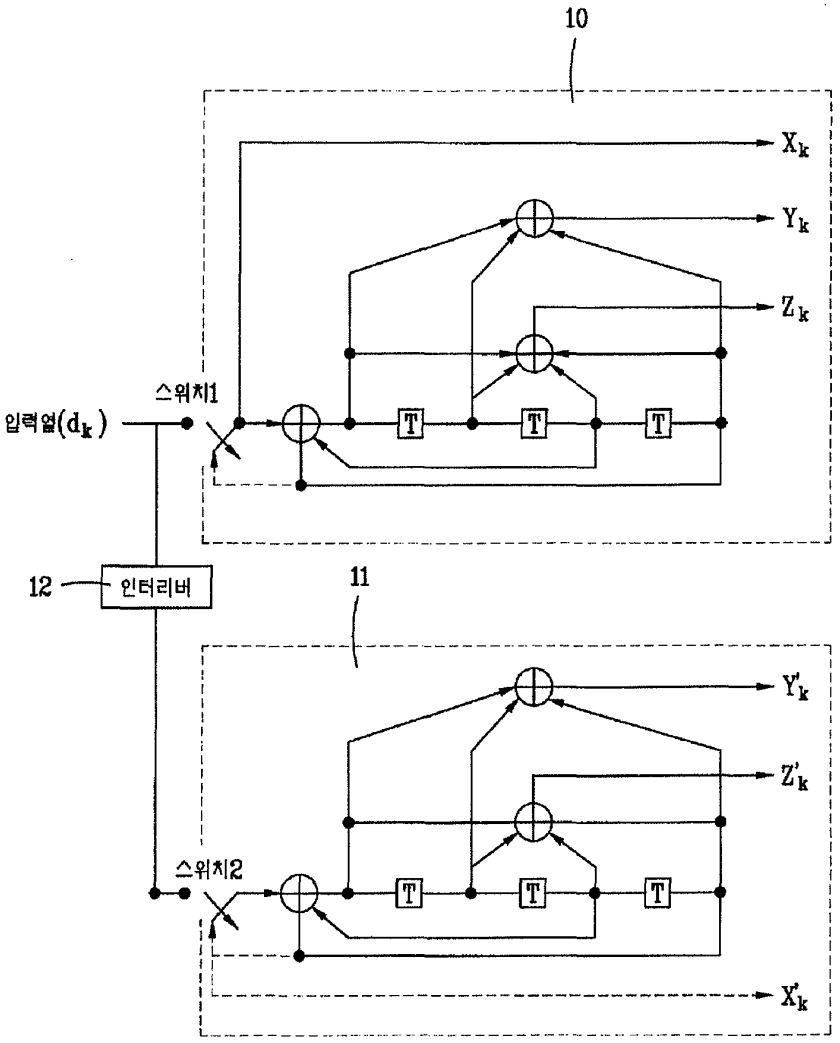
[0112] 한편, 상기 각 코드 그룹에 할당된 n개의 비트에서 각 비트의 인덱스가 1부터 (n-1)까지 증가하는 인덱스 j에 대하여, 상기 채널 코딩된 부호화열에 대한 제2 타입 그룹 개수의 정수배값을 상기 채널 코딩 부호화열의 입력 비트열로 나눈 나머지가 상기 채널 코딩 부호화열에 대한 제2 타입 코드 그룹의 개수보다 작고, (j+ 오프셋의 절대값)을 (n-1)로 나눈 나머지가 (제1 타입 코드 그룹내에서 제2 반복 팩터를 갖는 비트의 개수-1)보다 작거나 같은 경우 , 또는 상기 채널 코딩된 부호화열에 대한 제2 타입 그룹 개수의 정수배값을 상기 채널 코딩 부호화열의 입력 비트열로 나눈 나머지가 상기 채널 코딩 부호화열에 대한 제2 타입 코드의 그룹 개수보다 크거나 같고, (j + 오프셋의 절대값)을 (n-1)로 나눈 나머지가 (제1 타입 코드 그룹내에서 제2 반복 팩터를 갖는 비트의 개수-1)보다 작은 경우 현 코드 그룹내의
시스테메틱 비트에 대해 비트 반복을 수행하도록 한다.

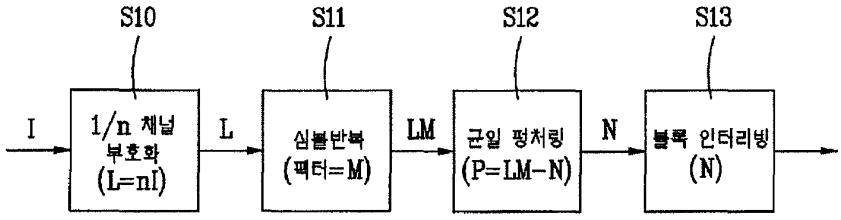
[0113] 또는 상기 각 코드 그룹에 할당된 n개의 비트에서 각 비트의 인덱스가 1부터 (n-1)까지 증가하는 인덱스 j에 대하여, 상기 채널 코딩된 부호화열에 대한 제2 타입 그룹 개수의 정수배값을 상기 채널 코딩 부호화열의 입력 비트열로 나눈 나머지가 상기 채널 코딩 부호화열에 대한 제2 타입 코드 그룹의 개수보다 크거나 같고 또는 (j+ 오프셋의 절대값)을 (n-1)로 나눈 나머지가 (제1 타입 코드 그룹내에서 제2 반복 팩터를 갖는 비트의 개수-1)보다 큰 경우 , 그리고 상기 채널 코딩된 부호화열에 대한 제2 타입 그룹 개수의 정수배값을 상기 채널 코딩 부호화열의 입력 비트열로 나눈 나머지가 상기 채널 코딩 부호화열에 대한 제2 타입 코드의 그룹 개수보다 작거나 (j+ 오프셋의 절대값)을 (n-1)로 나눈 나머지가 (제1 타입 코드 그룹내에서 제2 반복 팩터를 갖는 비트의 개수-1)보다 크거나 같은 경우 해당 비트에서 제1 반복 팩터로 비트 반복을 수행하도록 한다.

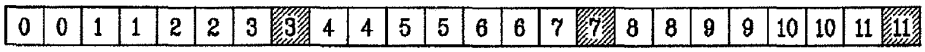
[0114] 이상의 설명에서와 같이 본 발명은 현재의 3GPP2시스템에서 터보 코드를 사용하는 경우, 가변 데이터 레이트(flexible data rate)를 지원하기 위한 반복 알고리즘의 설계시, 코드 그룹 단위의 반복 알고리즘을 설계함으로써 에너지의 분포를 두개의 구성 부호화기의 각각에 대하여 균일하게 줄 수 있으며, 이로 인하여 복호 성능을 향상시킬 수 있다

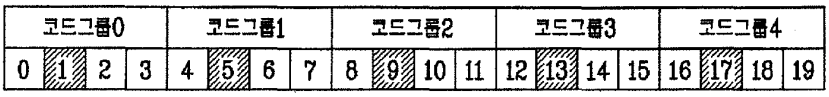
[0115] 이상 설명한 내용을 통해 당업자라면 본 발명의 기술 사상을 일탈하지 아니하는 범위에서 다양한 변경 및 수정이 가능함을 알 수 있을 것이다.

[0116] 따라서, 본 발명의 기술적 범위는 실시예에 기재된 내용으로 한정하는 것이 아니라특허 청구 범위에 의해서 정해져야 한다.


10
X_k
Y_k
Z_k
스위치1
입력열(d_k)
T
T
T
12
인터리버
11
Y'_k
Z'_k
스위치2
T
T
T
X'_k


S10
S11
S12
S13
I
1/n 채널 부호화 (L=nI)
L
심볼반복 (팩터=M)
LM
균일 펑처링 (P=LM-N)
N
블록 인터리빙 (N)


0 0 1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9 10 10 11 11


코드그룹0
코드그룹1
코드그룹2
코드그룹3
코드그룹4
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19


코드그룹0
코드그룹1
코드그룹2
코드그룹3
코드그룹4
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

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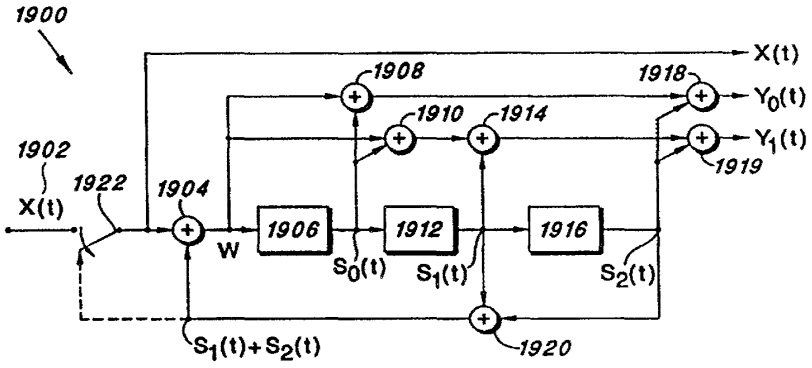
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(54) Title: OPTIMIZED RATE–COMPATIBLE TURBO ENCODING



UNIVERSAL CONSTITUENT ENCODER RECOMMENDED FOR FORWARD LINK TURBO CODES OF VARYING INTERLEAVER DEPTH

(57) Abstract

A method and apparatus for Turbo encoding uses a set of rate–compatible Turbo Codes optimized at high code rates and derived from a universal constituent code. The Turbo Codes have rate–compatible puncturing patterns. The method comprises: encoding a signal at a first and second encoder using a best rate 1/2 constituent code universal with higher code rates, the first encoder and the second encoder each producing a respective plurality of parity bits for each information bit; puncturing the respective plurality of parity bits at each encoder with a higher rate best puncturing patterns; and puncturing the respective plurality of parity bits at each encoder with a lower rate best puncturing pattern. In a variation, the best rate 1/2 constituent code represents a concatenation of polynomials $1+D^2+D^3$ (octal 13) and $1+D+D^3$ (octal 15), D data bit. A Turbo Encoder is provided which has hardware to implement the method.

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OPTIMIZED RATE-COMPATIBLE TURBO ENCODING

CLAIM FOR PRIORITY

This application claims priority under 35 U.S.C. § 1.119(e) of the filing dates of U.S. Provisional Applications Nos. 60/072,368, filed January 23, 1998, 60/074,932, filed February 17, 1998, 60/075,742, filed February 23, 1998, and 60/076,464, filed March 2, 1998.

BACKGROUND OF THE INVENTION

The present invention relates to error correction in data communications, and more particularly, to forward error correction (FEC). Even more particularly, the present invention relates to the selection and use of optimal Turbo Codes in high performance data communication systems, such as emerging third generation terrestrial cellular mobile radio and satellite telephone systems, for which flexibility in supporting a wide range of system requirements with respect to transmission data rates, channel coding rates, quality of service measures (e.g., latency, bit-error rate, frame error rate), and implementation complexity is highly desirable.

Forward error correction (FEC) is required in terrestrial and satellite ratio systems to provide high quality communication over the RF propagation channel, which induces signal waveform and spectrum distortions, including signal attenuation (freespace propagation loss) and multi-path

induced fading. These impairments drive the design of the radio transmission and receiver equipment, the design objective which is to select modulation formats, error control schemes, demodulation and decoding techniques and hardware components that together provide an efficient balance between system performance and implementation complexity. Differences in propagation channel characteristics, such as between terrestrial and satellite communication channels, naturally result in significantly different system designs. Likewise, existing communication system continue to evolve in order to satisfy increased system requirements for new higher rate or higher fidelity communication services.

In the case of terrestrial cellular mobile radio telephony, Analog Mobile Phone System (AMPS) is an exemplary first generation system; the U.S. IS-136 and European GSM time-division multiple-access (TDMA) standards and the U.S. IS-95 code-division multiple-access (CDMA) standard are second generation systems; and the wideband CDMA standards currently under development (e.g., CDMA 2000 in the U.S. and UTRA in Europe) are third generation systems.

In the third generation systems the development of flexible, high-speed data communication services is of particular interest. Desirable features include the ability to perform rate adaptation and to satisfy a multiplicity of quality-of-service (QOS) requirements.

Traditional forward error correction (FEC) schemes for communication systems include use of convolutional codes, block codes such as Reed-Solomon or BCH codes, and/or concatenated coding schemes.

Turbo Codes are a relatively new class of block codes that have been demonstrated to yield bit error rate (BER)

performance close to theoretical limits on important classes of idealized channels by means of an iterative soft-decision decoding method.

A Turbo encoder consists of a parallel concatenation of typically two systematic, recursive convolutional codes ("constituent codes") separated by an interleaver that randomizes the order of presentation of information bits to a second constituent encoder with respect to a first constituent encoder. The performance of a Turbo Code depends on the choice of constituent codes, interleaver, information block size (which generally increases with higher data rates), and number of decoder iterations. For a particular Turbo Code, in which the constituent codes are fixed, one can ideally adjust the block size and number of decoder iterations to tradeoff performance, latency and implementation complexity requirements. As the block size changes, however, a new interleaver matched to that block size is required.

In a CDMA network with synchronized base stations, forward link channels (from base station to user terminal) can be designed to be orthogonal, using, for example, Walsh-Hadamand spreading sequences. This is generally not possible, however, for reverse link channels (from user terminal to base station), which therefore operate asynchronously using spreading sequences that are only quasi-orthogonal. Thus, the reverse links in a synchronous CDMA network typically experience more interference and therefore may require stronger FEC (via lower rate codes) than the forward link channels do.

In an asynchronous CDMA network, the forward and reverse link channels are more similar in terms of interference

levels, so it is possible to use a common FEC scheme (or at least more similar FEC schemes) on the two links.

The flexibility and high performance of Turbo Codes make them a potentially attractive technology for sophisticated data communications services. It is therefore desirable to identify Turbo Codes and Turbo coding FEC schemes that best match diverse service requirements with respective data rates and coding rates while minimizing implementation complexity.

The present invention advantageously addresses the above and other needs by providing methods for designing and using universally optimized Turbo Codes and rate-compatible puncturings to support incremental redundancy schemes such as automatic repeat request (ARQ).

SUMMARY OF THE INVENTION

In its most basic form, the invention can be characterized, in one embodiment as a method of processing data, in data services, with a set of rate-compatible Turbo Codes optimized at high code rates and derived from a universal constituent code, the Turbo Codes having compatible puncturing patterns. The method comprises: encoding a signal at a first and second encoder using a best rate 1/2 constituent code universal with higher and lower code rates, the first encoder and the second encoder each producing a respective plurality of parity bits for a data bit; puncturing the respective plurality of parity bits at each encoder with a higher rate best puncturing pattern; and puncturing the respective plurality of parity bits at each encoder with a lower rate best puncturing pattern.

In a variation, a method of processing data in data services uses a set of rate-compatible Turbo Codes derived

from an optimal universal rate 1/3 constituent code, the Turbo Codes having similar constituent codes and compatible puncturing patterns, and comprises: encoding a signal with a best rate 1/3 constituent code at a first and a second encoder, each encoder producing a respective plurality of parity bits for each data bit; puncturing the plurality of parity bits with the a higher rate best puncturing pattern; and puncturing the plurality of parity bits with a lower rate best puncturing pattern.

In another variation, a method of rate-compatible Turbo encoding uses a set of rate-compatible Turbo Codes, the set optimized for code rate 1/4, comprising Turbo Codes with differing code rates and rate-compatible puncturing patterns. The method comprises: encoding a signal at a first and second encoder using a best rate 1/4 constituent code universal with higher and lower code rates, the first encoder and the second encoder each producing a respective plurality of parity bits for a data bit; puncturing the respective plurality of parity bits at each encoder with a higher rate best puncturing pattern; and puncturing the respective plurality of parity bits at each encoder with a lower rate best puncturing pattern.

In another embodiment, an encoding system uses a set of rate-compatible Turbo Codes derived from a best universal rate 1/2 constituent code, the set having compatible puncturing patterns, and comprises: a first and second encoder, each encoder comprising: a plurality of shift registers; a plurality of adders each adder coupled to a selected portion of the adders in a configuration corresponding to the best universal rate 1/2 constituent code; and a puncturer configured with the first and second encoder to puncture a

plurality of data outputs from each of the first and second encoder, the puncturing determined by a desired Turbo Code rate in accordance with the set of the compatible puncturing patterns.

In a further variation, an encoding system uses a set of rate-compatible Turbo Codes derived from an optimal universal rate 1/3 constituent code, the rate compatible Turbo Codes having similar constituent codes and compatible puncturing patterns, and comprises: a first and second encoder, each encoder comprising: a plurality of shift registers; a plurality of adders, each of the adders coupled to a selected portion of the adders in a configuration corresponding to the rate 1/3 constituent code of; and a puncturer configured with the first and second encoder such to puncture a plurality of data outputs from the first and second encoder, the puncturing determined by a desired Turbo Code rate in accordance with the set of the compatible puncturing patterns.

Yet another variation of the system uses a set of rate-compatible Turbo Codes comprising Turbo Codes having a universal constituent code and rate-compatible puncturing patterns for different code rates, and comprises: a plurality of shift registers; a plurality of adders each adder coupled to a selected portion of the plurality of adders in a configuration corresponding to the universal constituent code; and a puncturer configured with the first and second encoder for puncturing a plurality of data outputs from the first and second encoder, the puncturing determined by a desired Turbo Code rate in accordance with the set of compatible puncturing patterns.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other aspects, features and advantages of the present invention will be more apparent from the following more particular description thereof, presented in conjunction with the following drawings wherein:

Figure 1 is a diagram of a code-division multiple-access (CDMA) digital cellular mobile radio system hardware;

Figure 2 is a diagram of a CDMA digital cellular mobile radio system hardware which can implement an embodiment of the present invention;

Figure 3 is a functional block diagram of a Turbo Code encoder modified for use with the present invention;

Figure 4 is a functional block diagram of a generic turbo decoder;

Figures 5, 6, 7, 8 illustrate the Bit Error Rate (BER) performance against signal to noise ratio (SNR) for Turbo Code rates 1/2 and rate 1/3 at Interleaver sizes 1000, 512 and 1024 bits when the Turbo Codes use a candidate constituent code represented by d(D) and n(D);

Figure 9 illustrates the puncturing schemes studied for optimizing the rate 1/4 Turbo Codes;

Figures 10, 11, 12 illustrate the BER/FER performance of Constituent Codes #1-3 at a frame size of 512 bits;

Figure 13 illustrates the BER/FER performance of Constituent Code #1, wherein Constituent Code #1 is at a frame size of 1024 bits, and with consistent results found at sizes 2048 and 3072 bits, respectively;

Figure 14 illustrates the BER/FER performance of selected rate 1/4 Turbo Codes at frame size 512, with consistent results found at sizes 1024, 2048 and 3072 bits, respectively;

Figure 15 is a comparison of preferred Turbo Code B against other puncturing schemes at frame size 512 bits;

Figure 16 is a lay-out of candidate puncturing patterns for Turbo Codes of rate 1/3 and 1/2 when the constituent codes have rate 1/3;

Figure 17 illustrates a comparison of rate 1/3 puncturing schemes at frame size 512 bits;

Figure 18 illustrates rate 1/2 puncturing schemes at frame size 512 bits, with consistent results found at 1024, 2048 and 3072 bits, respectively;

Figure 19 illustrates a block diagram of a preferred universal constituent encoder for Turbo Codes optimized at code rate 1/2 and rate 1/3 of varying Interleaver depths;

Figure 20 is a functional block diagram for rate 1/4 Turbo Codes optimized at code rate 1/2 and rate 1/3, including interleaving and puncturing, (rate 1/3, and rate 1/2 use analogous processing);

Figure 21 illustrates puncturing patterns for rate 3/8 Turbo Codes;

Figure 22 illustrates rate 3/8 Turbo Codes optimized at code rate 1/2 and rate 1/3 at frame size 512 bits, wherein results are consistent at 1024, 2048 and 3072 bits, respectively;

Figure 23 illustrates puncturing patterns for rate 4/9 Turbo Codes;

Figure 24 illustrates rate 4/9 Turbo Codes optimized code rate 1/2 and rate 1/3 using frame size 512 bits;

Figure 25 is a functional block diagram of a preferred constituent encoder for a Turbo Codes optimized at code rate 1/4;

Figure 26 illustrates a functional block diagram of a rate 1/4 Turbo Codes optimized at rate 1/4, including interleaving and puncturing, (rate 1/3 and rate 1/2 use analogous processing);

Figure 27 illustrates puncturing patterns for rate 2/9 Turbo Codes;

Figure 28 illustrates rate 2/9 Turbo Codes optimized at code rate 1/4 using frame size 512 bits;

Figure 29 illustrates initial puncturing patterns for rate 3/8 Turbo Codes;

Figure 30 illustrates rate 3/8 Turbo Codes optimized at code rate 1/4 using frame size 512 bits;

Figure 31 is a functional block diagram of a preferred universal constituent encoder for rate 1/2 and rate 1/3 Turbo Codes of varying Interleaver depths; and

Figure 32 illustrates a performance comparison of rate 1/4 FER-optimized Turbo Codes with convolutional codes, at frame size 512 bits, wherein results are consistent at 1024, 2048 and 3072 bits.

Appendix A is a compilation of figures collectively referred to herein as 'analogous' figures, curves or simulations or the equivalent.

Corresponding reference characters indicate corresponding components through out several views of the drawings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The following description of the presently contemplated best mode of the invention is not to be taken in a limiting sense, but is made merely for the purpose of describing the general principles of the invention. The scope of the invention should be determined with reference to the claims.

There are two primary aspects of the current invention: 1) forward error correction (FEC) schemes for data services based on specific 'universal' Turbo Codes demonstrated to provide near-optimal performance over a wide range of information block sizes and code rates; and 2) the method by which specific Turbo Codes having the above mentioned desirable properties can be designed.

Turbo Codes are particularly well-suited to data applications because of their excellent error correction capabilities at low signal-to-noise (SNR) ratios and their flexibility in trading off bit error rate (BER) and frame error rate (FER) performance for processing delay. The data services under consideration in the hereinafter-described embodiments are consistent with third generation Code Division Multiple Access (CDMA) cellular mobile radio standards currently in development and are typically more delay-tolerant than low-rate voice services.

The universal Turbo Codes specified herein (and the method of finding such codes), however, are also applicable to data services in other cellular mobile radio systems (e.g., the European Time-Division Multiple Access (TDMA) standard used in GSM) as well as other systems, such as satellite or other wireless communications systems. Several specific Turbo Codes are therefor identified that provide different optimizations regarding these requirements. Others would also be possible.

In order to optimize the performance of Turbo Codes for data services, it is desirable to have a set of "universal" constituent codes that provide optimal or nearly optimal performance in conjunction with a variety of different

Interleaver depths and Turbo Code rates, thus avoiding tailoring each optimization of particular Turbo Codes.

Referring first to Figure 1, an exemplary conventional digital cellular mobile radio system using Direct Sequence Code Division Multiple Access (CDMA) Mobile-station-to-base-station (or reverse) link is shown using a convolutional encoder and a Viterbi decoder. This basic coding and interleaving can be applied, equally well, to other multiple access systems such as the Time Division Multiple Access (TDMA) used in a well-known GSM standard.

Figure 1 also represents a base-station-to-mobile-station (or forward) link in a cellular mobile radio system. At a transmitting system 100, the system comprises a segmentation processor 104 where user information bits from a data terminal equipment (not shown) are assembled into fixed length frames of N bits per frame 106 which are input to a convolutional encoder 108, (of rate r). Convolutional encoder 108 is coupled to a synchronization and framing processor 104 which produces N/r code symbols 110 at an input of a Channel Interleaver 112 coupled to the convolutional encoder 108. The channel interleaver 112 performs pseudo-random shuffling of code symbols 110 and outputs the code symbols 110 to a Spread Spectrum modulator 114 coupled to the channel interleaver 112. The Spread Spectrum modulator 114 uses a user specific Transmit PN-code generated by a PN converter 116 coupled to the Spread Spectrum modulator 114 to produce a spread spectrum signal carried on a RF carrier to a mobile RF transmitter 118. Mobile RF transmitter 118 is also coupled to the Spread Spectrum modulator 114, where a high power amplifier (not shown) coupled to a transmit antenna 120 radiates a signal to a base station. The techniques of spread spectrum modulation

and RF transmission are well known art to one familiar with spread spectrum communication systems.

A signal from a mobile station ($A_{\text{mobile signal}}\cong$) $A_{\text{mobile signal}}\cong$ received at a base station Receive antenna 122 is amplified in a Base RF receiver 124 and demodulated in a spread Spectrum demodulator 128 using the same PN-code used by the mobile RF transmitter 118 to de-spread the signal. The demodulated symbols are de-interleaved by a Channel De-Interleaver 130 and input to a Viterbi decoder 132. The decoded information bits are reconstructed into receive data blocks 136 and forwarded to the data terminal equipment at the receive end of the system.

Referring next to Figure 2, a hardware system for a digital cellular mobile radio system is shown which implements an embodiment of the present invention. As before, a reverse link is illustrated although the same block diagram represents a forward link. Further, while the CDMA system is used as an example, one familiar with the art would consider the present invention applicable to other systems such as TDMA as well.

Transmit data blocks 202 from data terminal equipment is segmented and framed at a Segmentation Processor 204 into fixed frame length and applied to a Turbo Code encoder 208. An output from the encoder 208 is fed to a Channel Interleaver 212 to pseudo-randomize the code symbols. The Channel Interleaver 212 provides output to a Spread Spectrum Modulator 214 which uses a user specific PN-code from a PN Generator 216 to create a spread spectrum signal, carried on a RF carrier to a mobile RF transmitter 218. The channel interleaver 212 is distinguished from a Turbo Code interleaver (not shown) which is a component of the encoder 208. The mobile RF Transmitter 218, coupled to a Transmit Antenna 220, uses a high power

amplifier (not shown) at the Transmit Antenna 220 to radiate the signal to the base station.

A signal from the mobile station received at a base receive antenna 222 is amplified in a base RF receiver 224 and demodulated in a spread Spectrum demodulator 228, which uses the same PN-code as used by the mobile RF transmitter 218, to de-spread the signal. The demodulated symbols are de-interleaved by the Channel DE-Interleaver 230, and input to the Turbo Code decoder 232. Decoded information bits from Turbo Code decoder 232 are reconstructed at a Reconstruction Processor 234 into receive data blocks 236 and forwarded to the data terminal equipment at the receive end.

Referring to Figure 3, the basic structure of a Turbo Code is characterized by the parallel concatenation of two simpler constituent codes at encoder #1 306 and encoder #2 308. Both constituent encoders, i.e., encoder #1 306 and encoder #2 308 process the same information bit stream 302, but the encoder #2 308 processes information bits 302 in a different order than the order in which encoder #1 306 processes the information bits 302, since the Interleaver 304 reorders the information bits in a pseudo-random manner before they reach encoder #2 308 (the constituent encoder 308). This arrangement reduces the likelihood that a sequence of information bits 302 causing encoder #1 306 to produce a low-Hamming weight output 310 would also cause encoder #2 308 to do the same with its output 314, which makes possible the excellent performance of Turbo Codes.

Both encoders 306, 308 produce, in addition to the information bits 302 (also referred to as systematic bits 302), parity bits 310, 314 which are punctured by puncturer

312 to achieve a desired overall Turbo Code rate. It is also possible to puncture systematic bits.

The constituent codes of a Turbo Code are usually systematic, recursive convolutional codes. The simplest and most widely known recursive convolutional codes have rate 1/2 and transfer function:

$$G(D) = [1, n(D)/d(D)],$$

where n(D) and d(D) are binary polynomials specifying the feed forward and feedback connections of the encoder, respectively.

The rate of a Turbo Code is changed by changing the selection of output bits 310, 314 for puncturing or transmitting. In all the cases herein, a "1" indicates transmitting; a "0" indicates puncturing.

Figure 3 also shows how two possible puncturing patterns result from puncturer 312. Alternately puncturing the parity bits between encoder 306 and 308 result in a Turbo Code rate r=1/2. Transmitting all of the parity bits at the two encoders 306, 308 produce a code rate r=1/3.

It is not possible to achieve lower Turbo Code rates lower than 1/3 without either increasing the number of constituent encoders or increasing the number of output parity bits per constituent encoder. The latter is usually preferred in order to reduce implementation complexity. In this case, one considers a rate 1/3 systematic, recursive convolutional code with transfer function:

$$G(D) = [1, n_1(D)/d(D), n_2(D)/d(D)].$$

Using two such constituent codes provides any Turbo Code rate between 1/5 and 1 through puncturing, or deleting.

Turbo Codes are decoded using iterative decoding methods as shown in the block diagram of Figure 4.

Each of the constituent codes are decoded separately using likelihood estimates of the other constituent decoder 406 or 416 as 'a priori' information. The constituent decoder 406, 416 must be of a soft-input/soft-output type, such as the Maximum A Posteriori (MAP) algorithm, the sub-optimal Soft-Output Viterbi Algorithm (SOVA), or variations. After both constituent decoders have processed the data, the process can be repeated.

In practice, the turbo decoders 406, 416 are usually limited to a fixed number of iterations consistent with the implementation complexity and performance objectives of the system.

Figure 4 is a general block diagram of a turbo decoder. Soft information regarding the information bits 404, parity bits for the first encoder 402, and parity bits of the second encoder 402' are received from the demodulator. First, a first decoder 406 uses received information bits 404 and received parity bits 402 to produce a soft decision 408 on information bits. The soft decision 408 is interleaved by an interleaver 412, the output of which is soft decision 414. Soft decision 414 is fed to a second decoder 416 as a priori information.

The second decoder 416 accepts the soft decision 414 described above and produces an improved soft decision 420 on information bits which are then interleaved by an interleaver 422 and fed to the first decoder 406 as a priori information. The whole process is repeated as many times as desired.

Final output 420 is obtained by making hard decisions or the soft decisions out of the first or second decoder.

In accordance with the present invention, a single mother Turbo Code and various puncturing patterns are sought to derive uniformly good codes for various code rates and information block sizes.

A methodology for determining universal constituent codes is developed by first limiting the initial pool of possible universal constituent codes in accordance with trade-off studies between performance and implementation complexity. In accordance with the present invention, performance studies using different state codes have shown that eight-state constituent codes provide a good performance trade-off.

Universal constituent codes are first optimized according to the primary code rate of the targeted application. For example, in the case of CDMA data communications, separate optimizations can be done for the forward and reverse links since the reverse links usually requires lower code rates for higher coding gain.

The following steps, more fully described below, are used to produce Turbo Codes optimized for rate 1/2 and 1/3:

1) select candidate systematic rate 1/2 constituent encoders with transfer function of the form $G(D) = [1, n(D)/d(D)]$, where $d(D)$ is a primitive polynomial and $n(D)$ starts with 1 and ends with D^3;

2) determine a Turbo Code rate 1/2 and rate 1/3 test puncturing pattern to apply to output data encoded by two rate 1/2 constituent encoders;

3) form all possible rate 1/2 and 1/3 Turbo Codes by combining each rate 1/2 constituent code pair with the test patterns;

4) evaluate a relative BER performance of all possible rate 1/2 and 1/3 Turbo Codes at a fixed Interleaver length;

5) select from the group of mother pairs, a subgroup of candidate pairs for building optimized Turbo Codes based upon a best overall BER performance;

6) evaluate another relative BER performance of a Turbo Code group comprising the subgroup of candidate pairs punctured with the rate 1/2 and rate 1/3 puncturing patterns at a plurality of other Interleaver depths;

7) select from the Turbo Code group, a universal code pair which has another best overall relative BER for the Interleaver depths; and

8) encode data with a rate 1/2 or rate 1/3 Turbo Code comprising the selected universal code pair, at a first and a second encoder, the encoders similar, and an Interleaver feeding bits into the second encoder, wherein the bits are ordered differently before entering each encoder.

Once generated, best Turbo Codes of lower rates such as 1/4, which are compatible with the rate 1/2 and 1/3 Turbo Codes determined by the above steps, can also be determined.

Rate 1/2 Constituent Codes

The following describes how rate 1/2 constituent codes are determined in one embodiment.

First, a list of candidate eight-state, rate 1/2 constituent code polynomials are determined.

Table 1 lists the determined denominator polynomials d(D) and numerator polynomials n(D) in octal notation. There are twelve constituent code candidates considered for initial screening purposes.

Table 1. Candidate 8-State Constituent Encoders of Rate 1/2

Denominator Polynomial d(D) (octal notation)	Numerator Polynomial n(D) (octal notation)
11	13
11	15
11	17
13	11
13	15
13	17
15	11
15	13
15	17
17	11
17	13
17	15

Each of the twelve (12) polynomials is expressed in octal form in Table 1, and has a corresponding binary and polynomial notation. The binary equivalent, for example of octal 13, is binary 1011. Binary 1011 corresponds to a polynomial

$$d(D) = D^0(1) + D^1(0) + D^2(1) + d^3(1) = 1 + D^2 + D^3.$$

Next, the candidate Turbo Codes are simulated with an interleaver size of 1000 bits and three decoder iterations. The preliminary screening, which results are shown in Figure 5 and Figure 6, evaluates the Bit Error Rate (BER) versus Ebi/No performance of all candidate Turbo Codes of rate 1/2 and rate 1/3 as it is described above. Measurement of Ebi/No is equivalent to a relative SNR.

The results of Figure 5 and Figure 6 are used to select six (6) code polynomial pairs. The six (6) candidate

universal code pairs, d(D)-n(D), are shown in octal representation on the left hand side of Table 2 below.

Next, a corresponding performance of the eight-state Turbo Codes, using simulated data with the candidate universal codes at each rate and Interleaver depth, is used to construct Table 2. A sample performance study or simulation is shown in Figures 7 and 8 showing selected Turbo Codes at an Interleaver depth of 512 bits for rate 1/2 and rate 1/3.

Table 2 below shows the approximate SNR loss for simulated data due to using a non-optimized code at rates 1/2 and 1/3 and Interleaver depths of 512, 1024, 2048, and 3072 bits.

Table 2. Approximate SNR Loss due to Use of Non-Optimized Codes

Candidate "Universal" Code: d(D)-n(D)	Turbo Code Rate & Frame Size (bits)							
	1/2 & 512	1/2 & 1024	1/2 & 2048	1/2 & 3072	1/3 & 512	1/3 & 1024	1/3 & 2048	1/3 & 3072
15-13	0.005 dB	0.00 dB	0.00 dB	0.05 dB	0.10 dB	0.05 dB	0.05 dB	0.10 dB
13-15	0.00	0.00 dB	0.00 dB	0.00 dB	0.05 dB	0.05 dB	0.05 dB	0.05 dB
15-17	0.05 dB	0.05 dB	0.00 dB	0.05 dB	0.05 dB	0.05 dB	0.00 dB	0.10 dB
17-15	0.40 dB	0.50 dB			0.00 dB	0.00 dB	0.05 dB	0.00 dB
17-13	0.40 dB	0.50 dB			0.00 dB	0.00 db	0.00 dB	0.00 dB
13-17	0.05 dB	0.05 dB	0.05 dB	0.00 dB	0.00 dB	0.10 dB	0.00 dB	0.10 dB

In a similar simulation using sixteen-state codes, pairs denoted as 31-33 and 31-27 are also shown in sample Figures 7 and 8 using four (4) decoder iterations for each sixteen-state code in order to provide similar complexity comparison with the eight-state codes using eight (8) decoder iterations.

Eight-state codes with eight iterations out perform sixteen state codes with four iterations significantly.

With separate simulations, the difference in performance amongst the different interleavers using the above six (6) candidate pairs is observed to be within 0.05 dB.

Finally, the results of Table 2 show that the following rate 1/2 constituent code pair provides the best overall performance across the ranges of rates and Interleaver sizes studied:

$d(D)=1+D^2+D^3$; $n(D)=1+D+D^3$,

which represents octal 13 and octal 15 respectively.

In each tabulated case, the performance of Codes 13-15 is within 0.05 dB to the best performing code for that rate and Interleaver size.

This constituent code is thus selected as the basis for Turbo Code designs where higher code rates such as 1/2 and 1/3 are dominant.

Rate 1/3 Constituent Code

The following describes how rate 1/3 constituent codes are determined. Similar to the rate 1/2 constituent codes, rate 1/3 constituent code candidates are identified in Table 3 below for building near optimal Turbo Code rates of 1/4 and 1/5. For this case, the constituent code candidates for a Turbo Code must have three (3) polynomials instead of two (2).

Table 3. Candidate Constituent Codes for Optimized Lower-Rate Turbo Codes

CC#1 (Octal 13-15/17)	CC#2 (Octal 15-13/17)	CC#3 (Octal 17-13/15)

$d(D)=1+D^2+D^3$ (Octal 13) $n_1(D)=1+D+D^3$ (Octal 15) $n_2(D)=1+D+D^2+D^3$ (Octal 17)	$d(D)=1+D+D^3$ (Octal 15) $n_1(D)=1+D^2+D^3$ (Octal 13) $n_2(D)=1+D+D^2+D^3$ (Octal 17)	$d(D)=1+D+D^2+D^3$ (Octal 17) $n_1(D)=1+D^2+D^3$ (Octal 13) $n_2(D)=1+D+D^3$ (Octal 15)

Optimal Rate 1/4 Turbo Codes

In order to build an overall rate 1/4 Turbo Code, various puncturing schemes must be considered in combination with each constituent codes of Table 3.

The various puncturing schemes of Figure 9 are first considered. For a rate 1/4 code, a common input information bit or systematic bit, is transmitted by one encoder, along with three (3) of four (4) parity bits produced for that input bit, by the two encoders.

The puncturing patterns of Figure 9, namely 910, 920, 930 and 940 are selected based upon the previously mentioned design principles, to meet stipulated code rates.

Next, each of the three (3) code triads of Table 3 is combined with the four (4) puncturing patterns 910, 920, 930 and 940, of Figure 9 to produce twelve (12) possible Turbo Codes to be evaluated with simulated data shown in Figure 10 through 12 for a fixed Interleaver depth of 512, for example.

Next, the performance of the twelve (12) Turbo Codes above is used to select three (3) best Turbo Code candidates for a more detailed evaluation. Based on the simulation results shown in Figures 10 through 12, the three (3) best Turbo Code candidates from the twelve (12) are:

Turbo Code A - Constituent Code No. 1 with puncturing Pattern No. 2;

Turbo Code B - Constituent Code No. 2 with puncturing Pattern No. 1; and

Turbo Code C - Constituent Code No. 3 with puncturing Pattern No. 1. (Puncturing patterns are selected from Figure 9, Patterns 910, 920, 930 and 940).

One of the Turbo Codes of Codes A through C is next selected for further evaluation using simulated data at various additional Interleaver frame sizes to verify that the puncturing patterns are also good at other Interleaver depths.

To confirm the basic methodology, the performance of a Turbo Code based upon Constituent Code No. 1 (for example) is simulated for frame sizes of 1024, 2048 and 3072 bits. Sample results for BER/FER performance of Code #1 at 1024 bits is shown in Figure 13 and confirms the basic methodology.

Next, Figure 14 shows the BER/FER performance of simulated data using the three rate 1/4 Turbo Code Candidates A through C at an Interleaver depth of 512 bits. Consistent results are also achieved at Interleaver sizes 1024, 2048 and 3072 bits.

Next, a rate 1/4 Turbo Code candidate is selected from Candidate Turbo Codes A through C which provides the best overall performance at all Interleaver depths, in the simulation resulting in Figure 14 and analogous figures, such as those depicted in Appendix A. In the case of the rate 1/4 Turbo Code, optimization based on BER performance gives a different result than optimization based on FER performance. Turbo Code B has the best overall FER performance and Turbo Code C the best overall BER performance, for the simulated data. Figure 15 shows the performance of Turbo Code B as compared to other puncturing schemes.

Thus, FER optimized Turbo Code B is selected as the basis for the design since FER performance is usually the more

important criteria for data services. On the other hand, Turbo Code A can be punctured to give the same universal Turbo Code identified previously as optimal for rate 1/3 (by puncturing all parity bits from the n_2 (D) polynomial). Hence, Turbo Code A is the preferred choice for the forward link rate 1/4 codes in order to have a single universal mother code to implement all of the different code rates.

Although current third generation CDMA encoding primarily concerns rate 1/4 channel encoding on the reverse link, rate 1/3 and rate 1/2 channel coding may be required for some of the highest rate data channels. A universal Turbo Code for rate 1/4, rate 1/3 and rate 1/2 can be designed, wherein the underlying constituent code is the same and only the puncturing pattern used is different. The method for generating the higher rate Turbo Codes from the rate 1/3 constituent code follows.

Rate 1/3 Turbo Codes Optimized at Rate 1/4

Using the constituent codes derived from the rate 1/4 optimized Turbo Codes above, namely Turbo Code B, the rate 1/3 and rate 1/2 Turbo Code can be designed to be compatible thereto. Thus, Constituent Code No. 2 (from Code B) is used as the basis.

Figure 16 shows seven (7) basic puncturing patterns that can be used to produce a rate 1/3 Turbo Code and four (4) basic puncturing patterns to produce a rate 1/2 Turbo Code. The seven (7) rate 1/3 patterns, 1602 through 1614 in block diagram 1600, show the consecutive information puncturing bit patterns, 1620, 1626, and the four (4) corresponding row parity bit puncturing patterns 1622, 1624, 1628, and 1630, for the two (2) encoder puncturing block patterns 1616 and 1618.

As before, the pattern "1111" shown in row 1620 always transmits all the information bits from encoder 1. The pattern "0000" of row 1626, always punctures the information bits that enter by encoder No. 2. This is because it is not necessary to transmit the information bit twice. The four (4) rate 1/2 puncturing patterns, 1 through 4, identified in Figure 16 as element numbers 1640, 1642, 1644, and 1646, follow the same notation.

Next, in Figure 17 the BER and FER performance of all possible rate 1/3 Turbo Codes simulated with the preferred Constituent Code No. 2 at an Interleaver depth 512 are compared.

Then the two (2) best patterns are selected for further consideration. Next, the performance of these two (2) patterns are compared at further Interleaver depths 1024, 2048 and 3078 bits.

In Figure 17, for example, showing the rate 1/3 puncturing patterns at 512 bits, Patterns 2 and 5 are selected based upon curves 1710 and 1720, as having the best and next best overall relative FER, respectively.

Pattern 2 is then selected as the best performer over the various Interleaver depths from further simulations analogous to that of Figure 17 at additional Interleaver sizes for 1024, 2048 and 3072 bits.

Rate 1/2 Turbo Codes Optimized at Rate 1/4

Rate 1/2 Codes can also be optimized at lower rate codes for similar compatibility as described above. Figure 18 compares the BER and FER simulated performance of all the rate 1/2 Turbo Codes at an Interleaver depth of 512 bits. Figure 18 is generated using Constituent Code No. 2 and the four (4)

puncturing patterns shown in Figure 16 for a rate 1/2 Turbo Code. Patterns 1 and 4 are determined to be the best based upon simulated curves 1810 and 1820 for FER performance.

As in the rate 1/3 case optimized at rate 1/4, similar simulation curves to Figure 18 are done for Patterns 1 and 4 for Interleaver depths of 1024, 2048 and 3072 bits. Based upon the resulting performance/curves Pattern 1 is judged to be the best pattern for FER performance.

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Preferred Universal Turbo Codes Optimized for Rate 1/2 and 1/3

Figure 19 shows a block diagram for the constituent encoder optimized in accordance with the previously described method for Turbo Code rates 1/2 and 1/3. Figure 20 shows the block diagram for the corresponding Turbo Code punctured to rate 1/4.

Information bit stream X(t) 1902 is received at a switch 1922, and is processed in accordance with several modular adders 1904, 1908, 1920, 1910, 1914, 1918, 1919, and several shift registers 1906, 1912 and 1916 which are hard-wired to represent two (2) numerator polynomials and one denominator polynomial.

In Figure 19, the denominator polynomial d(D), represented in octal 13, is hardwired by the return feedback connection to modular adder 1920 and 1904. Before computing, three shift registers 1906, 1912 and 1916 are first zeroed.

A first numerator polynomial over a denominator polynomial, represented by "1101" is hardwired to return output $Y_0(t)$ by combining: X(t) 1992 with a result of modulator adder 1920 to create a first bit W(t); the modular sum (second bit) of shift register 1906 and W(t) from the modular adder 1908; another zero bit (third bit) indicated by the lack of connection to the register 1912; and the modular sum (fourth bit) of another register 1916 and a result of modular adder 1908 from modular adder 1998. The result is $Y_0(t)=W(t)+S_0(t)+S_2(t)$.

In Figure 19 a second numerator polynomial over a denominator polynomial, represented by "1111", is hardwired to return output $Y_1(t)$ by combining: X(t) 1902 with a result of adder 1920 to create a first bit W(t); adding contents of a further register 1906 to W(t) with the contents of the modular

adder 1910 (second bit); adding contents of the register 1912 a result of adder 1710 with the modular adder 1914 (third bit); and adding contents of the other register 1916 to a result of adder 1914 with modular adder 1919 (fourth bit). The result is $Y_1(t)=W(t)+S_0(t)+S_1(t)+S_2(t)$.

In Figure 19, the denominator polynomial connections sum the result of the register 1912 with register 1916 at adder 1920 and then adds it to X(t) 1902 at adder 1904. Thus, if modular adder 1904 is the value W(t), register 1906 holds $S_0(t)$, register 1912 holds $S_1(t)$ and register 1916 holds $S_2(t)$, and adder 1904 produces $W(t)=X(t)+S_1(t)+S_2(t)$; $Y_0(t)=W(t)+S_0(t)+S_2(t)$; and $Y_1(t)= W(t)+S_0(t)+S_1(t)+S_2(t)$. Thus, the adding is cumulative.

The result of a modular adder is a "1" if the two bits are different, and a "0" if the two bits are the same. Output $Y_0(t)$ represents the output from numerator Polynomial No. 1 and the denominator polynomial. Output $Y_1(t)$ represents numerator Polynomial No. 2 and denominator polynomial.

Initially, $S_0=S_1=S_2=0$ and the values of the registers 1906, 1912, 1916 are shifted from left to right after each clock cycle increment. Thus, $S_0(t+1)=W(t)$; $S_1(t+1)=S_0(t)$, and $S_2(t+1)=S_1(t)$.

The optimal puncturing matrices, shown in Figure 20, for example, shows a "1" for transmitted bits and a "0" for punctured bits. Exemplary Figure 20 shows encoder 2000 with incoming bit X(t) and Interleaver 2002 passing interleaved bits $X'(t)$ to encoder 2006 to produce output bit $X'(t)$ and parity bits $Y_0^1(t)$, and $Y_1^1(t)$. None of the interleaved bits $x'(t)$ are processed in the rate 1/4 encoder 2004, only in the second rate 1/4 encoder 2006. Block 2010 shows the puncturing pattern matrices.

More complicated puncturing patterns can be used to achieve other possible coding rates. For example, it is possible to select optimal puncturing patterns to achieve rate 3/8 and 4/9 for Turbo Codes optimized at rates 1/2 and 1/3; and to achieve rates 2/9 and 3/8 for Turbo Codes optimized at rate 1/4 using the preferred Turbo Codes identified in the invention.

Similar to Figure 9 the block diagram for an optimal Turbo Code rate 3/8 uses the rate 1/3 mother constituent code of Figure 20. The encoder for the constituent code of Figure 20 is shown in Figure 19. The puncturing pattern of the rate 3/8 Turbo Codes shown in Figure 21 punctures 1 out of every 6 bits associated with the first numerator polynomial from both encoders to generate a rate 3/8 Turbo Code.

The second pattern is a extension of the first pattern allowing both constituent encoders to have the same rate, namely 6/11. The extension pattern duplicates the same pattern (matrix) for another three (3) bits but moves the location of one transmission bit from one encoder to another, essentially flipping a "1" in one encoder while flipping a "0" in another encoder at the analogous locations.

Figure 22 shows the performance of these patterns at an Interleaver depth of 512 bits. Based on these and analogous curves at 1024, 2048 and 3072 Interleaver depths, Pattern 2 is chosen to implement the rate 3/8 Turbo Codes.

Figure 23 shows the puncturing patterns selected for rate 4/9 Turbo Codes used with the mother of codes of Figure 20. Similarly, the second pattern is an extension of the first, which allows both constituent encodes to have the same rate, namely 8/13.

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Figure 24 shows the corresponding performance curves. Pattern 2 is chosen to implement the rate 4/9 Turbo Codes.

Thus, one exemplary Turbo Code design, optimized for Turbo Code rates 1/2 and 1/3, and universal for all Interleaver depths, has the preferred generator polynomials $d(D)=1+D^2+D^3$, $n_1(D)=1+D=D^3$, and $n_2(D)=1+D+D^2+D^3$.

The preferred puncturing patterns for various code rates are:

1) Rate 1/4 - alternately puncturing parity bits n_1 from one encoder and n_2 from the same encoder;

2) Rate 1/3 - puncturing parity bits n_2 from both encoders;

3) Rate 1/2 - puncturing parity bits n_2 and alternately puncturing parity bits n_1 from both encoders;

4) Rate 3/8 - puncturing parity bits n_2 and one out of every 6 parity bits n_1 from both encoders; and

5) Rate 4/9 - puncture parity bits n_2 and uniformly 3 out of every 8 parity bits n_1 from both encoders.

A simplified version of this code is the universal Turbo Code design consisting of two constituent encoders having generator polynomials $d(D)=1+D^2+D^3$ and $N_1(D)=1+D+D^3$. (The third polynomial $n_2(D)$ is not used, so the corresponding output is not generated and the encoder block diagram is simplified by removing the corresponding connections.) This universal Turbo Code design supports a minimum code rate equal to 1/3 (instead of 1/5). The corresponding preferred set of puncturing patterns are:

1. Rate 1/3 - no puncturing
2. Rate 1/2 - alternately puncturing parity bits n1 from both encoders;

3. Rate 3/8 - puncturing one out of every 6 parity bits n_1 from both encoders; and
4. Rate 4/9 - puncturing uniformly 3 out of every 8 parity bits n1 from both encoders.

Preferred Universal Turbo Codes Optimized for Code Rate 1/4

The basic block diagram for a preferred constituent encoder is shown in Figure 25.

Figure 26 is an encoder block diagram for the preferred rate 1/4 Turbo Code. In this case, the second parity bits are alternately punctured by the two constituent encoders. The preferred puncturing patterns described in earlier section can then be applied to produce rate 1/3 and rate 1/2 Turbo Codes. Other rates can also be supported by identifying further puncturing patterns. This is illustrated by considering rates 2/9 and 3/8.

Figure 27 shows the puncturing patterns for a 2/9 reverse link code. Three (3) different patterns are compared by performance curves in Figure 28 and analogous curves, such as those set forth, for example, in Appendix A, showing performance at various frame Interleaver sizes. From a Pattern 2 FER curve 2810 and analogous curves, Pattern No. 2 is chosen as the optimal FER pattern for rate 2/9.

Next, Figure 29 illustrates six (6) initial screening puncturing patterns for optimizing a rate 3/8 reverse link codes. The performance of these patterns is simulated at a fixed Interleaver length of 512 bits. Based on the simulation, Pattern 5 and Pattern 6, are chosen as the optimal puncturing patterns for further review.

Two more extension Patterns 7 and 8 of the above Patterns 5 and 6 duplicate the same patterns for another three

information bits, but move the location of one of the transmission bits in the parity sequence from one encoder pattern to another. The extension allows both constituent encoders to have the same rate, namely 6/11 at each encoder.

Figure 30 shows exemplary performance curves of the above four (4) candidate puncturing Patterns 5, 6, 7 and 8 for rate 3/8 Turbo Codes. Based on these results, a Pattern 8 FER curve 3010 and analogous curves such as those shown, for example, in Appendix A, demonstrate that Pattern 8 is the optimal puncturing pattern for rate 3/8 Turbo Codes.

Thus, one preferred Universal Turbo Code design optimized for Rate 1/4 uses two constituent codes having polynomials $d(D)=1+D+D^3$, $n_1=1+D^2+D^3$ and $n_2=1+D+D^2+D^3$.

The below puncturing patterns are associated optimized patterns as previously discussed for Turbo Code rate 1/4 and FER performance for most commonly used Turbo Code rates, where n_1 represents output bits associated with a first numerator polynomial, and n_2 represents output bits associated with a second numerator polynomial:

1) Rate 1/4 - alternately puncture parity bits n_2 from both constituent encoders.

2) Rate 1/3 - puncture parity bits n_1 from both constituent encoders;

3) Rate 1/2 - puncture parity bits n_2 and every other parity bits n_1 from both encoders;

4) Rate 2/9 - puncture every one out of every four parity bits in n_1 from both encoders; and

5) Rate 3/8 - puncture parity bits n_1 and one out of every six parity bits n_2.

These preferred puncturing patterns can also be cyclically shifted without affecting performance. The cyclically shifted patterns are equivalent.

Turbo Coding FEC Schemes for CDMA Data Services

The set of preferred universal Turbo Codes described heretofore in this invention provide a suite of flexible high performance channel codes that are well suited for sophisticated data communication systems requiring a variety of low speed and high speed data services. This suite of preferred universal Turbo Codes allows the crafting of different Turbo encoding schemes to meet the specific requirements of particular data communication systems.

As a first example, either of the following two FEC schemes is well-suited and recommended for a synchronous CDMA data communications network (such as the third generation CDMA 2000 system currently under development):

1) A preferred universal Turbo Code optimized at codes rates 1/2 and 1/3, along with a subset of associated preferred puncturing patterns, on a forward link; and a preferred universal Turbo Code optimized at code rate 1/4, along with a subset of the associated preferred puncturing patterns, on a reverse link; and

2) The preferred universal Turbo Code optimized at code rates 1/2 and 1/3, along with a subset of associated preferred puncturing patterns, on both the forward and reverse links.

As a second example, either of the following FEC schemes is well-suited and recommended for an asynchronous CDMA data communications network (such as the third generation UTRA system currently in development in Europe and Asia):

1) The preferred universal Turbo Code optimized at code rates 1/2 and 1/3, described above, along with a subset of associated puncturing patterns, on both the forward and reverse links;

2) The preferred universal Turbo Code optimized at code rate 1/4, described above, along with a subset of the associated preferred puncturing patterns, on both the forward and reverse links; and

3) The simplified version of the universal Turbo Code, described above, along with a subset of the associated preferred puncturing patterns, on both the forward and reverse links; and

The choice of which option to implement depends on the expected dominant code rate, minimum code rate, and implementation complexity constraints as well as other system requirements. Of course, additional puncturing patterns could be designed in accordance with the teachings of this invention to provide other Turbo Coding rates.

Other Variations

The universal Turbo Codes identified for high-speed data services are especially suitable for third generation CDMA cellular mobile radio systems but could be easily applied to other systems as well.

Well known variations such as Frame Oriented Convolutional Turbo Coding (FOCTC) could also be used in conjunction with the preferred universal constituent codes and universal Turbo Codes of this invention. The design methodology for selecting universal constituent codes and universal Turbo Codes can also be applied to alternate Turbo Code structures such as those involving more than two

constituent encoders, and those involving serial concatenation instead of or in addition to parallel concatenation.

The exemplary preferred puncturing patterns described herein can be refined or modified in various ways by those skilled in the art. For example, a cyclic shift of a preferred puncturing pattern offers substantially equivalent performance as the preferred puncturing pattern described herein. Furthermore, specific data communication systems may require different and additional puncturing patterns to support rate matching. These puncturing patterns may be designed in accordance with the teachings of the present invention.

Sets of Rate-Compatible Universal Turbo Codes

In accordance with the present invention, it is possible to provide sets of rate-compatible Turbo Codes that are uniformly optimal or nearly optimal over a AWGN channel for various code rates and various Interleaver depths by assuring that any given higher rate Turbo Code of a set transmits the same bit positions as transmitted by any other lower rate Turbo Code of a same set.

In particular, one embodiment includes a set of rate-compatible Turbo Codes at various code rates of 1/5, 1/4, 1/3 and 1/2 and also at various Interleaver depths from 512 to 3072 bits.

Another preferred embodiment provides multiple sets of Turbo Codes optimized under different conditions allowing a system designer to trade off degree of universality (and thus, complexity) with performance and vice a versa. The selection

of sets of rate-compatible Turbo Codes is based upon the universal constituent encoder described herein below.

The universal constituent encoder of the present invention provides optimal or nearly optimal performance over a large range of code rates and Interleaver depths. Different optimization criteria such as reverse link or forward link dominance and degree of universality, result in different sets of rate-compatible Turbo Codes.

The sets of rate-compatible codes are especially well suited for use in hybrid ARQ schemes applied in satellite broadcast and telephony.

Several preferred embodiments comprise different sets of rate-compatible codes based upon different universal constituent codes and different rate puncturing patterns optimized according to different design criteria.

Consistent with general methodologies of the present invention, four (4) different preferred sets of rate-compatible Turbo Codes are described herein. The first two (2) sets are optimized for high-rate Turbo Codes, wherein higher-rates dominate. The second two (2) sets are optimized for lower-rate codes, where lower-rates dominate. The sets are referred to herein as Sets A-D.

The first preferred set is derived from a best universal constituent code of rate 1/2.

The second set is derived from another best constituent code of rate 1/3 which is also compatible with the universal constituent code of rate 1/2.

The first set, "Set A" has two generator polynomials while the second set, "Set B" has three generator polynomials of which two are in common with "Set A". Thus, "Set B" is optimally compatible with "Set A", reducing the amount of

design changes for encoding and decoding. As before, the third polynomial is necessary for the additional encoder parity bits of a rate 1/3 or lower Turbo Code.

The second set, "Set B" includes "Set A" and also extends the family of Turbo Codes to rate 1/5 and higher.

A third and fourth preferred set of rate- compatible Turbo Codes are optimized for lower-rates, in particular for rate 1/4. "Set C" and "Set D", respectively, also use three generator polynomials which are the same as those in "Set B", but in a different order.

Rate-Compatible Set Derived from Universal Constituent Codes of Rate 1/2: Set A (Rates 1/3, 1/2)

From Table 2, it is determined that the rate 1/2 constituent code providing the best overall performance is octal pair 13-15. Thus, this constituent code pair is used as the mother constituent code pair for Set A.

Rate-compatible Set A comprises generator polynomials corresponding to octal pairs 13-15, wherein a denominator polynomial is $1+D^2+D^3$ (octal 13) and a numerator polynomial is $1+D+D^3$ (octal 15).

The puncturing patterns are designed such that all bits transmitted by a rate of 1/2 code (or higher rate) of the set are also transmitted by a rate 1/3 code, or lower rate code of the set.

Exemplary preferred patterns as demonstrated by simulations and design principles are:

1) For rate 1/3 there is no puncturing; and

2) For rate 1/2, the parity bits are alternately punctured between encoders. (Note that there is no second numerator polynomial encoding in this case.)

Figure 31 shows a block diagram for the Set A constituent encoder. In Figure 31, modular adders 3104, 3108 (connected to shift register 3106), and 3116 (connected to shift register 3114) comprise the encoding apparatus for a numerator polynomial representing octal 15 or binary 1101.

Modular adders 3104, 3108, 3112 and 3116 add the contents of shift registers 3106, 3110 and 3114 and X(t) in an analogous fashion as Figure 19.

Simulated performances of the rate 1/2 Turbo Code and the rate 1/3 Turbo Code show that the eight-state convolutional codes designed herein (with 8 decoder iterations) have a performance gain (BER) of about 1.6 dB at rate 1/2 and about 2.0 dB at rate 1/3 with respect to the best 256-state convolutional codes known, according to simulation data produced by the Applicant.

Thus, the Turbo Codes of Set A compare favorably in performance to the best known 256-state convolutional codes, when simulated for the critical performance parameters.

Rate-Compatible Set Derived from Universal Constituent Code of Rate 1/3: Set B (Rates 1/2, 1/3, 1/4, 1/5)

As in the case of determining universal constituent codes of rate 1/3 an additional output numerator polynomial is required for the rate-compatible generator polynomials of "Set B" derived from the best constituent code of rate 1/3.

Therefore, a second best individual rate 1/2 constituent code is chosen from Table 2. As before, this method results in two (2) octal pairs with an overlap. Both octal pairs, octal 13-15 and octal 13-17 provide uniformly excellent performance. Combining the two (2) pairs together provides three (3) generator polynomials, comprising the triad

octal 13-15/17. The denominator polynomial is $1+D^2+D^3$ (octal 13); the first numerator polynomial is $1+D^2+D^3$ (octal 15); and the second numerator polynomial is $1+D+D^2+D^3$ (octal 17). The preferred design for Set B comprises these generator polynomials above for all Interleaver depths and for Turbo Code rates 1/2, 1/3, 1/4 and 1/5.

In Set B the rate 1/3 and rate 1/2 Turbo Codes built from the rate 1/3 constituent encoder are the same 1/3 and 1/2 Turbo Codes in Set A built from the universal rate 1/2 constituent encoder, preserving the compatibility between Set A and Set B.

The puncturing patterns are designed such that all bits transmitted at any higher rate Turbo Code of Set B are also transmitted at any lower code rate of Set B.

Exemplary preferred patterns, as demonstrated by simulations and design principles, are:

1) Rate 1/5 - no puncturing;

2) Rate 1/4 - alternately puncture the second numerator parity bits, n_2;

3) Rate 1/3 - always puncture the second numerator parity bits, n_2; and

4) Rate 1/2 - always puncture the second numerator parity bits, n_2 and alternately puncture the first numerator parity bits, n_1.

For the rate 1/4 pattern the weaker of the two (2) output arms of the constituent encoders are alternately punctured.

For the rate 1/3 pattern, the weaker of the two (2) constituent encoder outputs is always punctured.

For rate 1/2 the weaker of the two (2) constituent encoder outputs is always punctured for both encoders and the stronger output is alternately punctured.

Rate-Compatible Set Optimized for Lower Turbo Code Rates

When higher code rates are the dominant modes Turbo Code Set B is the preferred design choice when strict rate-compatibility is required in all code rates.

Turbo Code Set C and Set D, both optimized at the lower Turbo Code rates, are useful when rate-compatibility between lower rate and higher rate Turbo Codes is not necessary.

The optimal Turbo Codes for rates 1/4 and 1/5 are selected based upon the candidate constituent codes listed in Table 3 which are selected based upon the results of Table 2 as previously described above.

Constituent Code No. 1 of Table 3, or octal 13-15/17, is the basis for code Set A. However, disbanding the requirement that the rate 1/4 puncturing pattern be rate-compatible with that of the rate 1/2 or 1/3 codes, in the event that lower rates are not used with higher rates, each three (3) mother Turbo Code triad of Table 3 is considered with each of four (4) different puncturing patterns to obtain a newly optimized 1/4 Turbo Code.

As described before, Turbo Codes A, B, and C are found optimal from respective performance curves 1010, 1110 and 1210 of Figures 10, 11 and 12 respectively.

As before, these puncturing patterns are also verified at other Interleaver depths by simulating the performance of the Turbo Codes based on mother code triad No. 1 for additional other Interleaver frame sizes of 1024, 2048 and 3072. Figure 13 shows a sample result of the simulation and confirms the basic methodology at 1024 bits.

Next, Figure 14 shows a sample corresponding performance of the triads matched with the selected puncturing patterns at

512 bits. From Figure 14 and analogous results for other Interleaver sizes, the best overall BER performance at all simulated Interleaver depths are used as a final design criterion to determine the optimal candidate.

Rate-Compatible Set Derived from Rate 1/4 Turbo Code: Set C (Rates 1/5, 1/4, 1/3)

Turbo Code Set C implements Code No. 3 and Pattern No. 1 (Turbo Code C) from Figure 9 in accordance with performance curve 1310 of Figure 14 and analogous curves for other Interleaver sizes.

Turbo Code Set C comprises a generator polynomial from Table 3 including denominator polynomial $1+D+D^2+D^3$, first numerator polynomial, n_1, $1+D^2+D^3$, and second numerator polynomial n_2, $1+D+D^2$. The optimal puncturing patterns from the simulation, as previously described and consistent with the methodology, are:

1) For rate 1/5 - no puncturing;

2) For rate 1/4 - alternately puncturing the second numerator polynomial; and

3) For rate 1/3 - always puncturing the second numerator polynomial.

Rate-Compatible Set Derived from Rate 1/4 Turbo Code: Set D (Rates 1/5, 1/4)

Turbo Code Set D comprises a single constituent code for all Interleaver depths and Turbo Code rates 1/4 and 1/5.

Turbo Code Set D implements Code No. 1 with Pattern No. 2 (Turbo Code A) from Figure No. 9 in accordance with performance curve 1420 of Figure 14 and analogous curves at other Interleaver sizes.

The set comprises generator polynomials including a denominator polynomial d, $1+D+D^3$, a first numerator polynomial, n_1, $1+D^2+D^2$ and second numerator polynomial, n_2, $1+D+D^2+D^3$.

The optimal puncturing patterns from the simulation previously described and consistent with the methodology is:

1) For rate 1/5 - no puncturing; and

2) For rate 1/4 - alternately puncture output 1/2.

Performance of the rate 1/4 FER optimized Turbo Code at selected Interleaver depths of 512 through 3072 bits are compared against convolutional codes in sample Figure 32 and analogous studies.

More complicated puncturing patterns may be used in convolutional coding to achieve any code rate greater than or equal to that of the base Turbo Code in each rate-compatible Set.

For example, rates higher than 1/2 or intermediate rates such as 5/12 can be achieved. With the appropriate choice of puncturing patterns this can often be done in a rate-compatible manner without sacrificing error correction performance.

Applications of Rate-Compatible Turbo Codes

An exemplary application of the rate-compatible turbo codes described herein is for rate matching in which the code rate is selected to match the payload of an available physical channel. In rate matching schemes, the data services use the same basic channel encoding but may not use the same physical channel, especially if the quality of service specifications are different for the different data services.

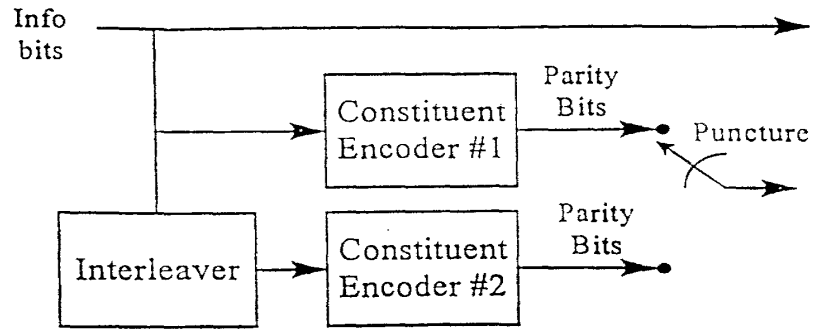
In accordance with the present invention, this is accomodated by selecting different puncturing patterns to produce the code rate compatible with the physical channel. If the puncturing patterns are rate-compatible, the selection of code rate does not have to be completed by single decision unit at a single point in time. Instead, the decision can be distributed in time as well as across decisioning units. The turbo encoder first produces the coded output sequence corresponding to the lowest code rate to be supported by the system. For example, all the possible parity bits might be output initially. Subsequently, an initial puncturing might be performed by one puncturing unit in response to say quality-of-service (QoS) considerations for the given data service. In this scenario, the data service may permit a range of quality-of-service in which, for example, the highest quality within that range does not require the lowest possible code rate available in the system but some intermediate code rate, and the lowest quality within that range can allow an even higher code rate. The first puncturing unit removes coded bits in accordance with the puncturing pattern corresponding to the lowest rate in order to provide the highest quality within the data service's QoS range. The non-punctured coded bits are output to the rest of the system for further processing. In the subsequent processing, a decision might be made to adjust the code rate higher for that message based on dynamic traffic management considerations. For example, a physical channel with smaller payload might be substituted, on a temporary as-needed basis, for the physical channel nominally associated with that data service in order to accomodate messages from a higher priority data service. The higher code rate is achieved by performing a second

puncturing in accordance with the puncturing pattern associated with the new code rate. Since the puncturing patterns are rate-compatible, it is not necessary to regenerate coded bits deleted by the first puncturing unit; the second puncturing unit simply deletes those bits specified by the higher rate puncturing pattern that have not already been deleted by the first puncturing unit.

A second exemplary application of the rate-compatible turbo codes described herein is for incremental redundancy schemes such as error control based on ARQ protocols. In these schemes, the turbo encoder first produces coded output corresponding to the highest code rate available in the system. When the coded output is transmitted across the communication channel, the receiver may or may not be able to successfully decode the message. If the message is not successfully decoded, the receiver typically sends a negative acknowledgement (NAK) back to the transmitter to request further transmissions to aide the decoding of that packet. With rate-compatible channel encoding, the extra encoded bits produced by one of the lower-rate compatible encodings for that packet can be sent to augment the information available to the decoder at the receiver. The decoder uses that new information along with the original information received for that packet to perform the decoding. The effect is as if the packet had been originally encoded with the lower rate code. This process can be repeated until the packet is successfully decoded. By only sending the excess coded bits each re-transmission, the traffic loading required for re-transmission is significantly lowered.

While the invention herein disclosed has been described by means of specific embodiments and applications thereof numerous modifications in variations could be made thereto by a skilled artisan and without departing from the scope of the invention set forth in the claims.

APPENDIX A



Generic Turbo Code Encoder Block Diagram

Appendix Fig. A-1

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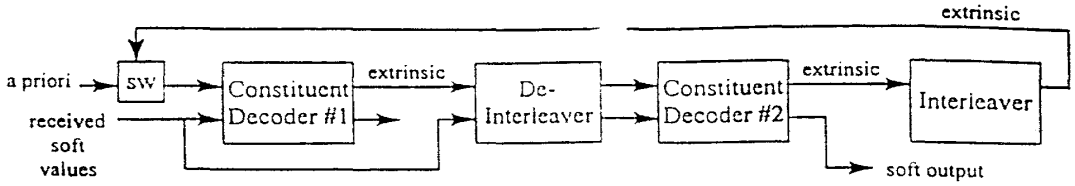
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Appendix Fig. A-2 Generic Turbo Decoder Block Diagram

The criterion for designing a good convolutional code is different from the conventional approach of maximizing minimum Hamming distance, when the convolutional code is used as a constituent code in turbo codes. In this case, the systematic, recursive convolutional code should be designed [1] so as to maximize the minimum parity weight corresponding to information sequences of weight two that cause the trellis diverge from the zero state and later remerge to it.

Due to the nature of the Turbo code construction, this design criterion depends in an essential way on the Turbo code's interleaver and puncturing scheme, thus requiring that the optimization be done for a specific interleaver depth and code rate. In the next section, we look at designing "universal" constituent codes that provides optimal or nearly optimal performance in conjunction with a variety of different interleaver depths and Turbo code rates.

Search for "Universal" Constituent Codes

In searching for universal constituent codes, we limit ourselves to 8-state constituent codes, since previous work has demonstrated that they provide the best trade-off between performance and implementation complexity. For the

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Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5	Pattern 6	Pattern 7
1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1
1 1 1 1	0 0 0 0	1 0 1 0	1 1 1 0	1 1 1 1	1 1 1 0	0 0 0 1
0 0 0 0	1 1 1 1	0 1 0 1	0 0 0 1	0 0 0 0	0 0 0 1	1 1 1 0
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0
1 1 1 1	0 0 0 0	1 0 1 0	0 0 0 1	0 0 0 0	1 1 1 0	0 0 0 1
0 0 0 0	1 1 1 1	0 1 0 1	1 1 1 1	1 1 1 1	0 0 0 1	1 1 1 0

(a) *Turbo Code Rate* = 1/3

Pattern 1	Pattern 2	Pattern 3	Pattern 4
1 1 1 1	1 1 1 1	1 1 1 1	1 1 1 1
1 0 1 0	0 0 0 0	1 0 0 0	1 0 1 0
0 0 0 0	1 0 1 0	0 0 1 0	0 0 0 0
0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0
0 1 0 1	0 0 0 0	0 0 0 1	0 0 0 0
0 0 0 0	0 1 0 1	0 1 0 0	0 1 0 1

(b) *Turbo Code Rate* = 1/2

Appendix Fig. A-3 **Essential Puncturing Patterns for Rate 1/3 Constituent Codes**

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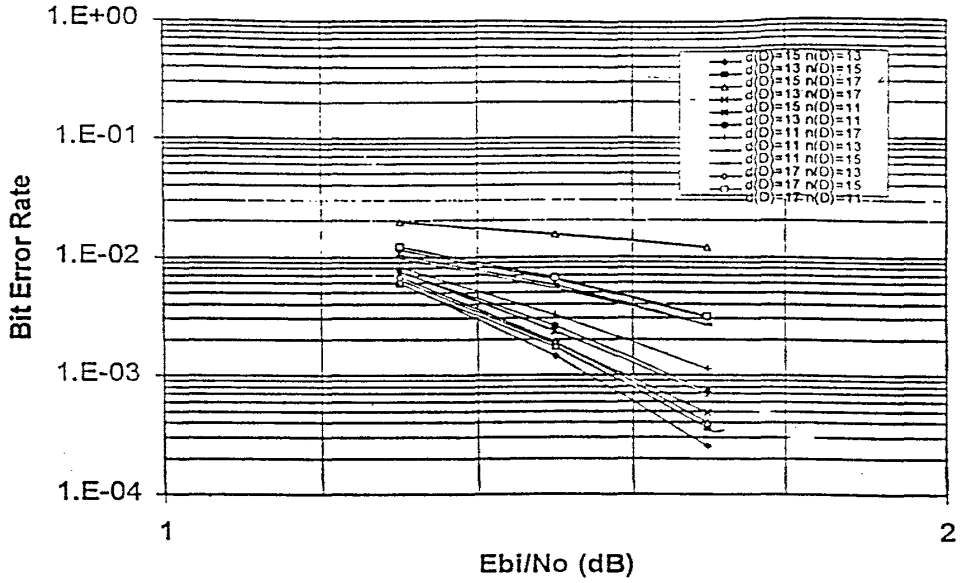
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Appendix Fig. A-4 Rate-1/2 turbo codes on AWGN channel. (1000 bit interleaver, 3 iterations)

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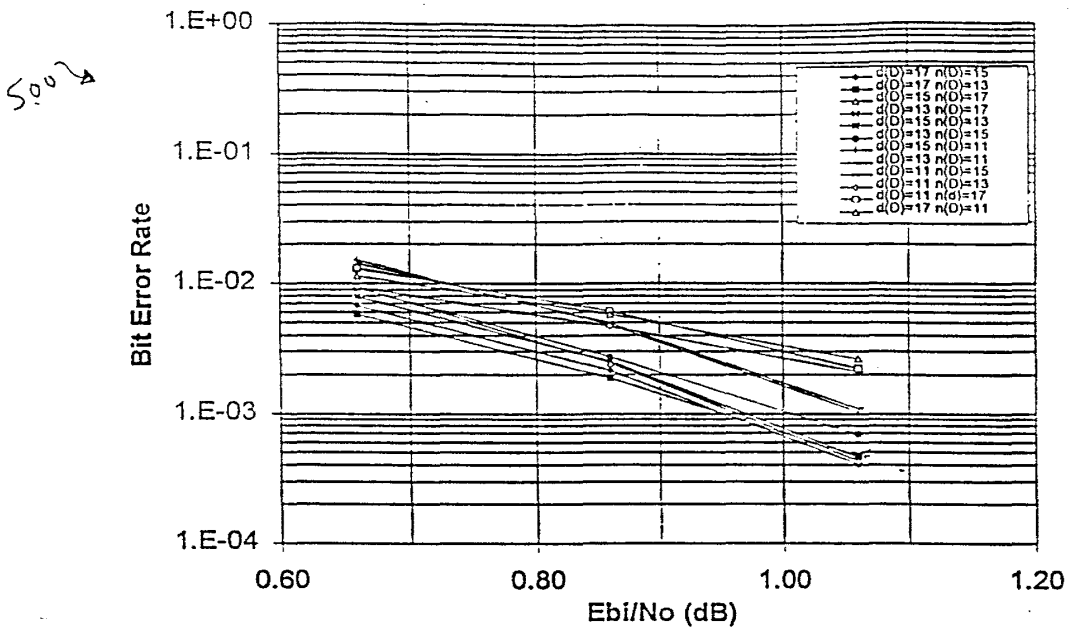
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Appendix Fig. A-5 **Rate-1/3 turbo codes on AWGN channel. (1000 bit interleaver, 3 iterations)**

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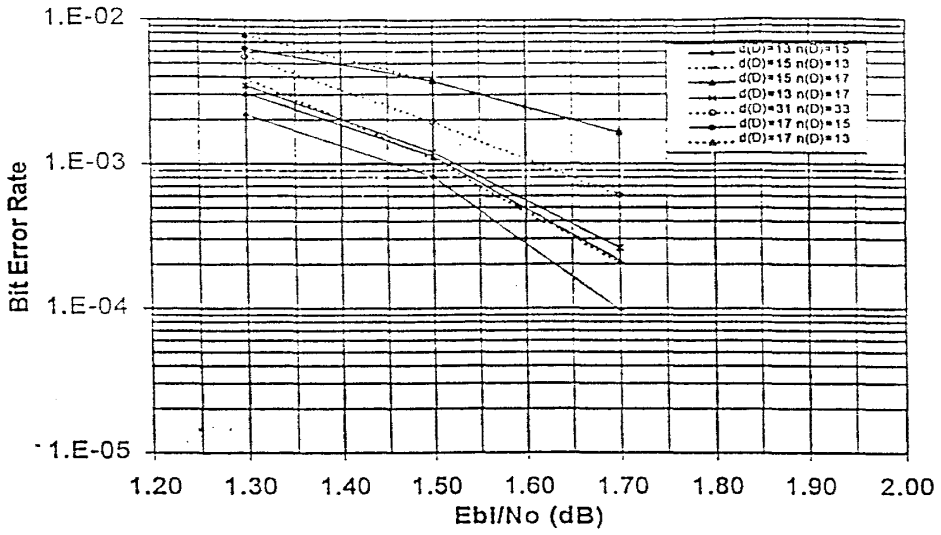
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Appendix Fig. A-6 **Selected rate 1/2 turbo codes on AWGN channel, 512 bit frame size**

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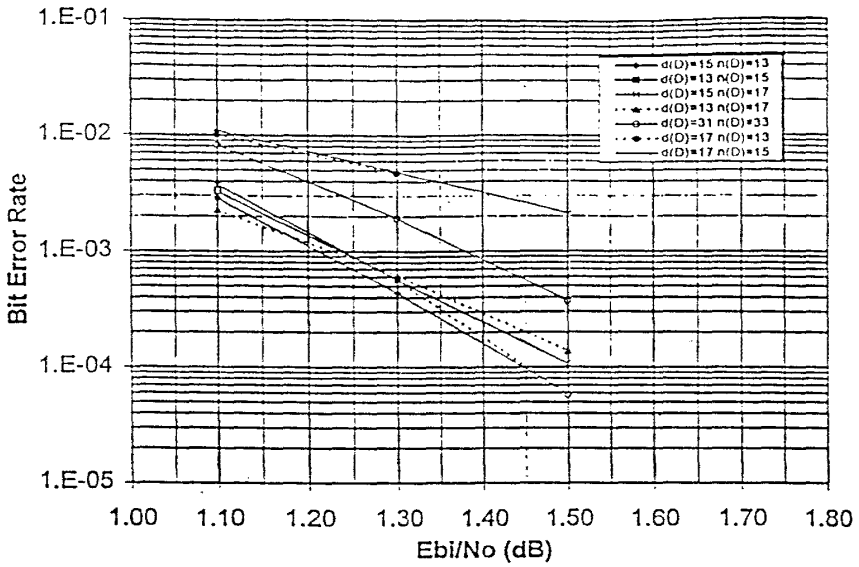
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Appendix Fig. A-7 **Selected rate 1/2 turbo codes on AWGN channel, 1024 bit frame size**

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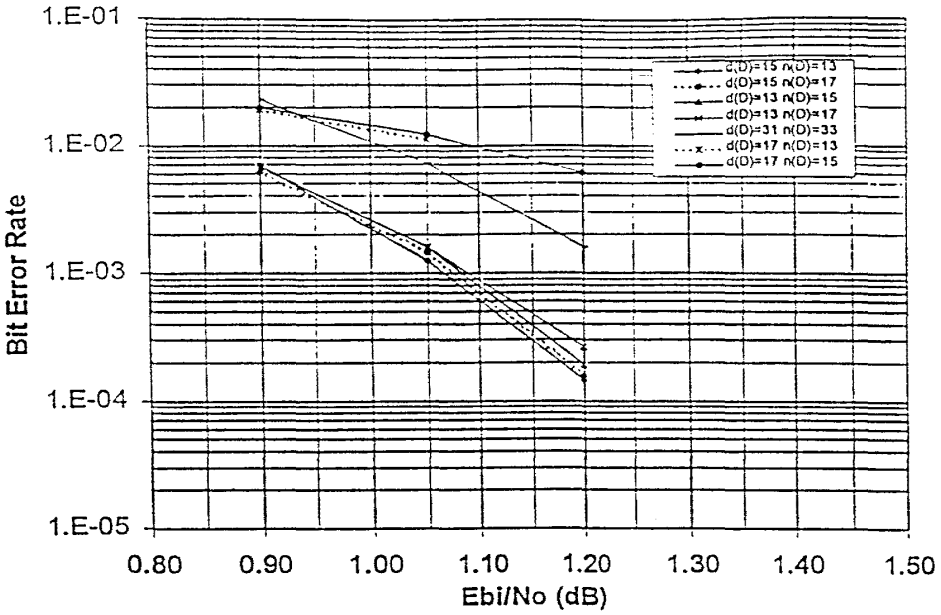
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Appendix Fig. A-8 Selected rate 1/2 turbo codes on AWGN channel, 2048 bit frame size

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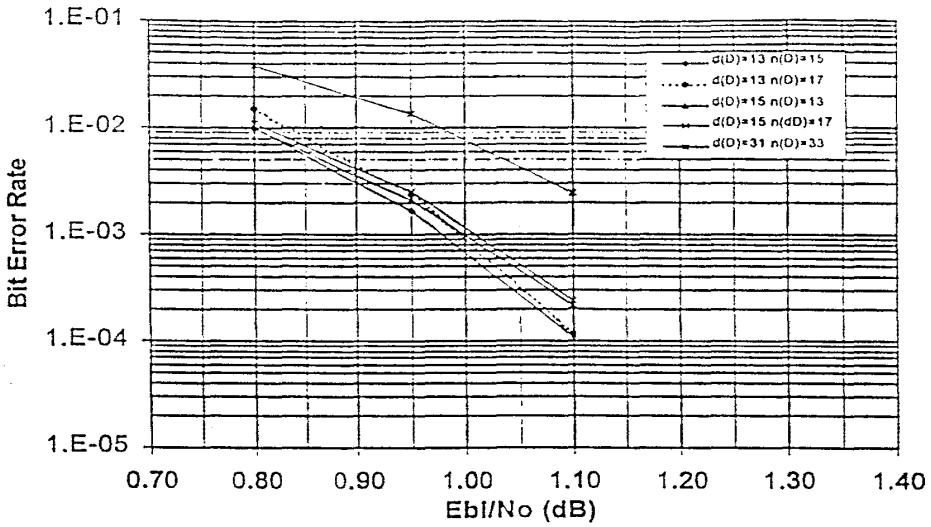
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Appendix Fig. A-9 Selected rate 1/2 turbo codes on AWGN channel, 3072 bit frame size

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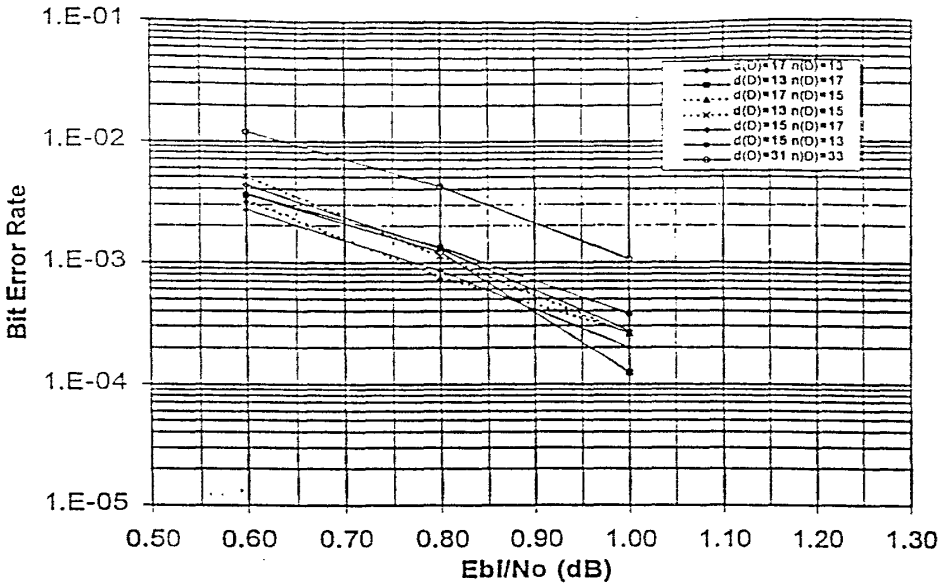
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Appendix Fig. A-10 **Selected rate 1/3 turbo codes on AWGN channel, 512 bit frame size**

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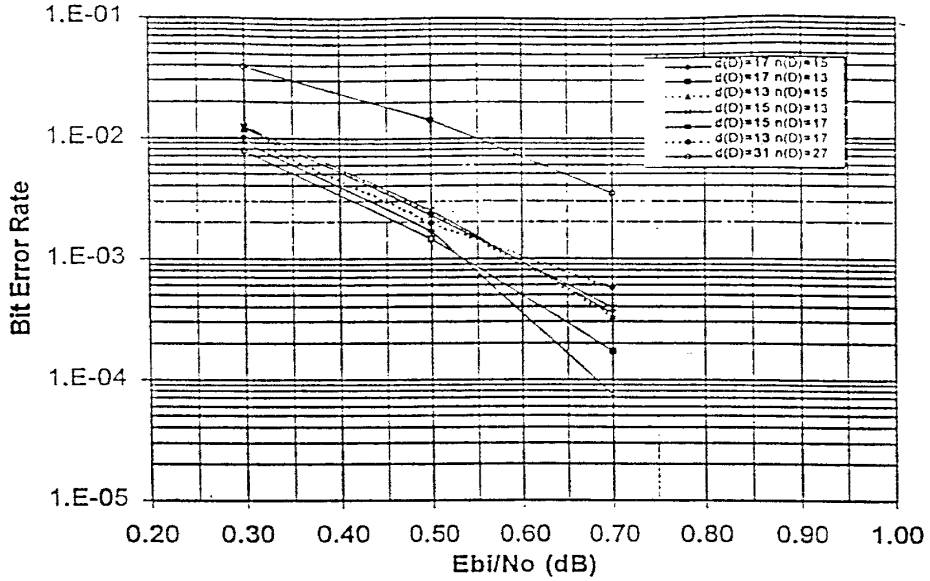
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Appendix Fig. A-11 Selected rate 1/3 turbo codes on AWGN channel, 1024 bit frame size

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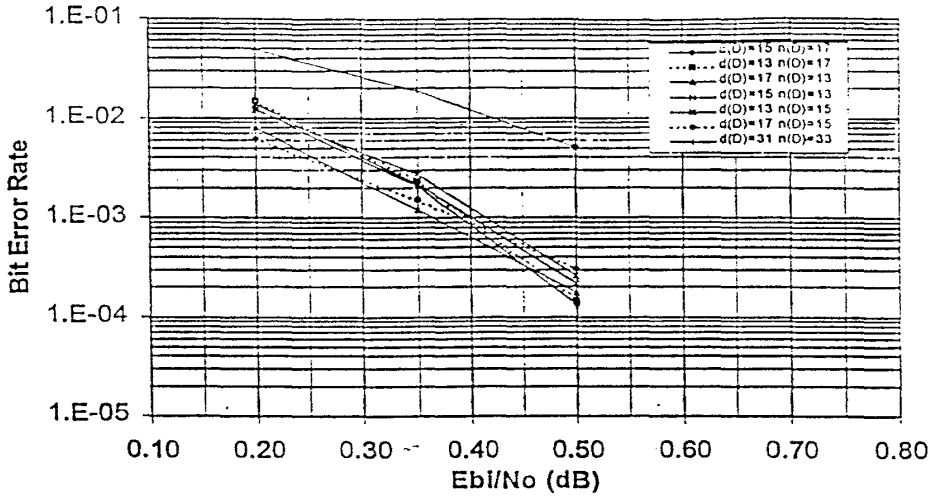
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Appendix Fig. A-12 Selected rate 1/3 turbo codes on AWGN channel, 2048 bit frame size

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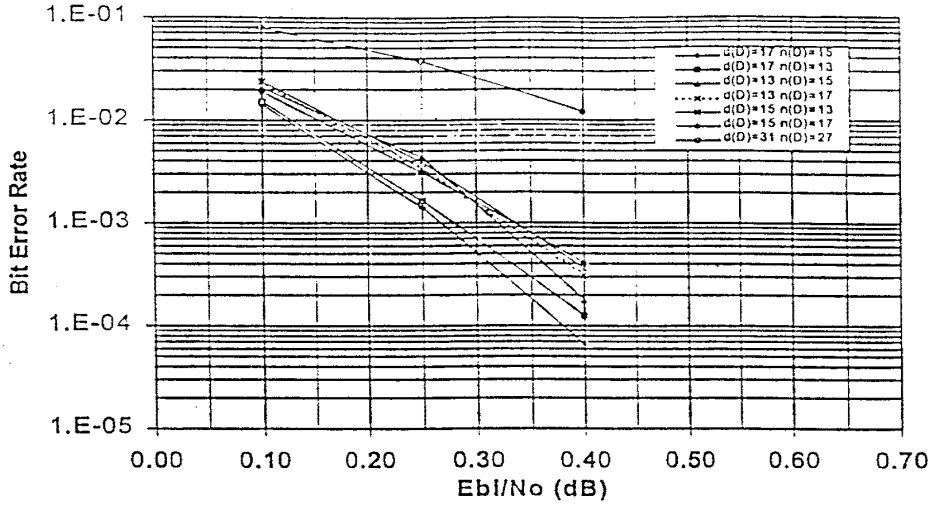
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Appendix Fig. A-13 Selected rate 1/3 turbo codes on AWGN channel, 3072 bit frame size

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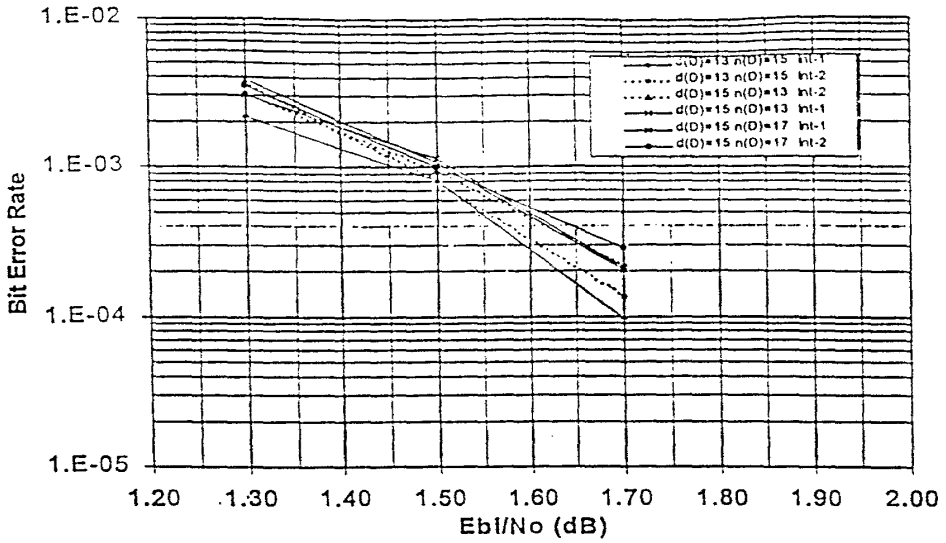
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Appendix Fig. A-14 Performance impact of different interleavers, rate=0.5, frame: 512 bits

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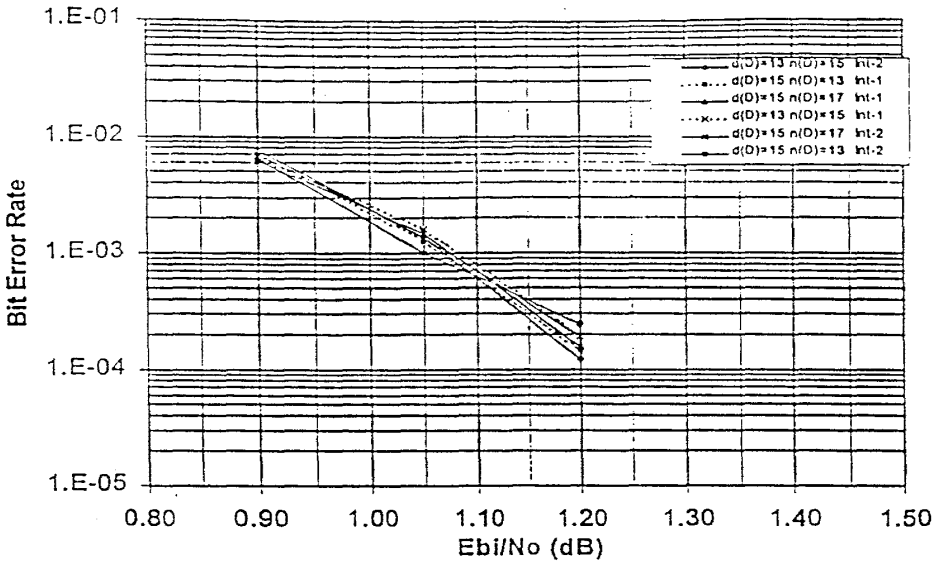
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Appendix Fig. A-15 The effect of different interleavers, rate=0.5, frame: 2048 bits

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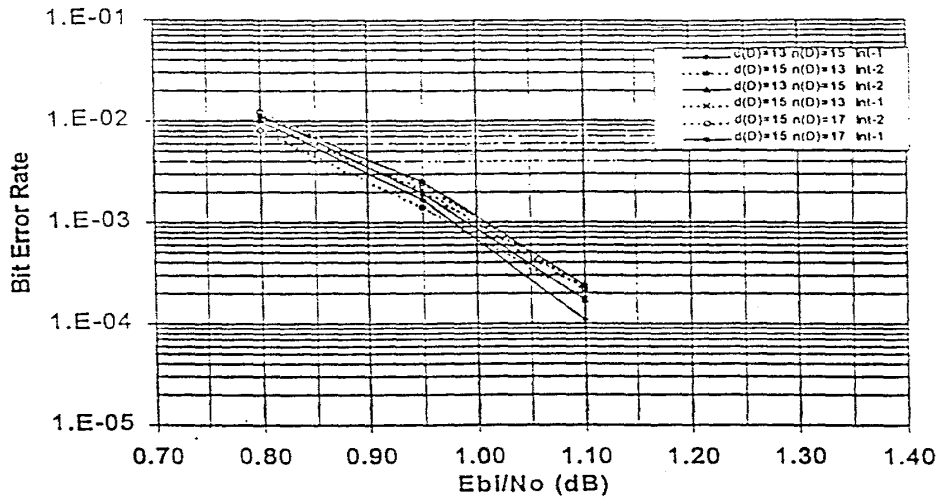
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Appendix Fig. A-16 The effect of different interleavers, rate=1/2, frame: 3072 bits

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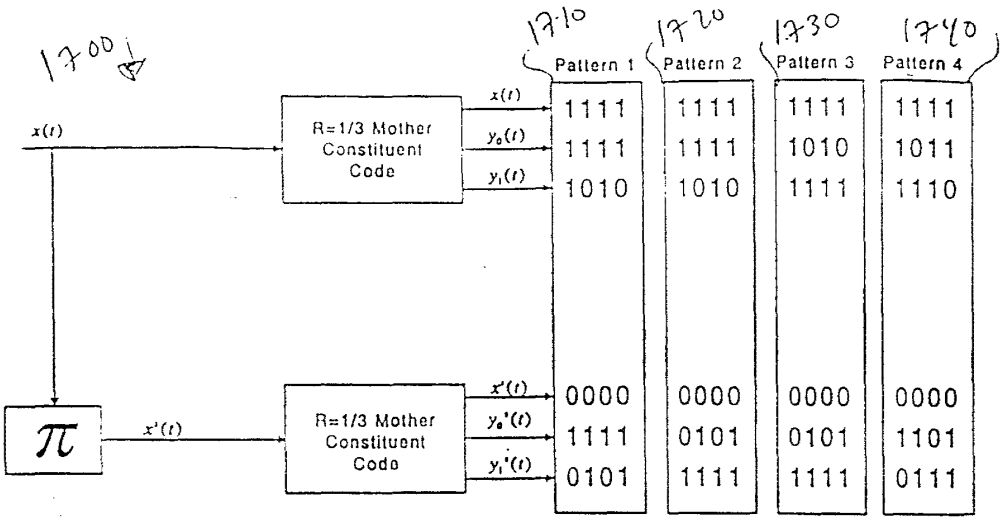
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Appendix Fig. A-17 Puncturing Schemes Studied for Optimizing the Rate 1/4 Turbo Code

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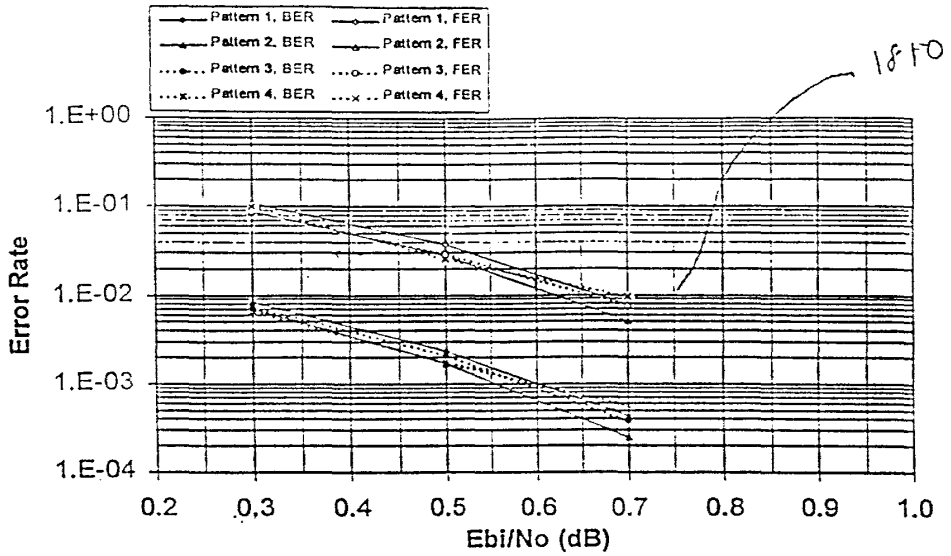
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Appendix Fig. A-18 Performance of Code #1, Frame Size=512

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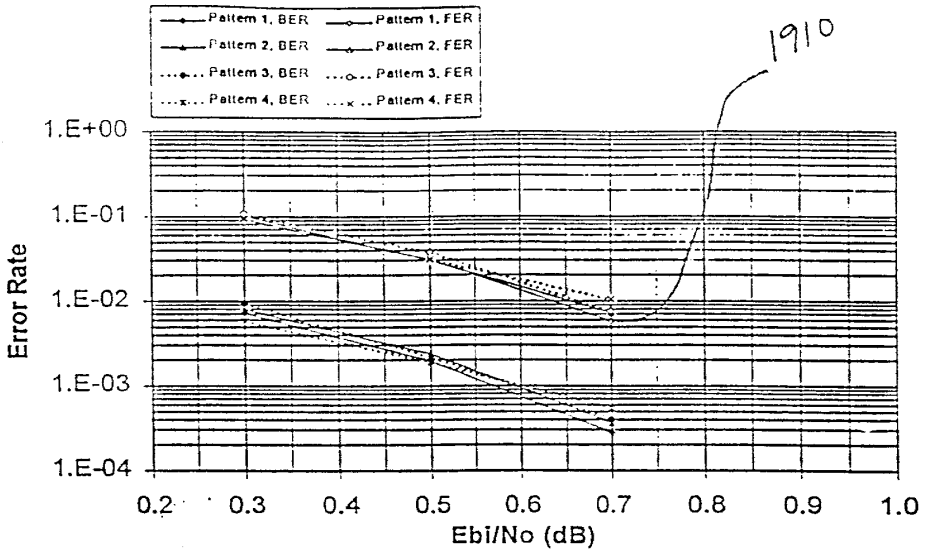
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Appendix Fig. A-19 Performance of Code #2, Frame Size=512

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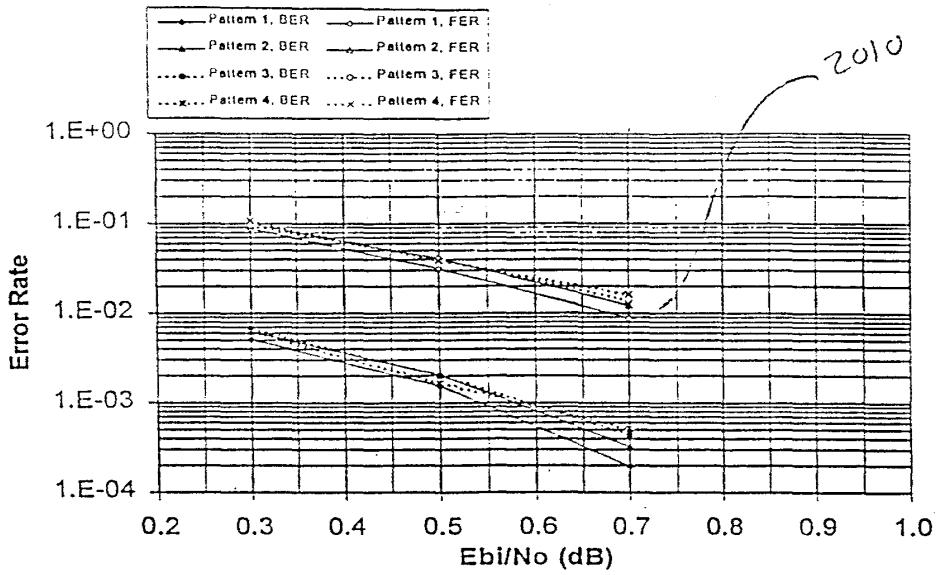
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Appendix Fig. A-20 Performance of Code #3, Frame Size=512

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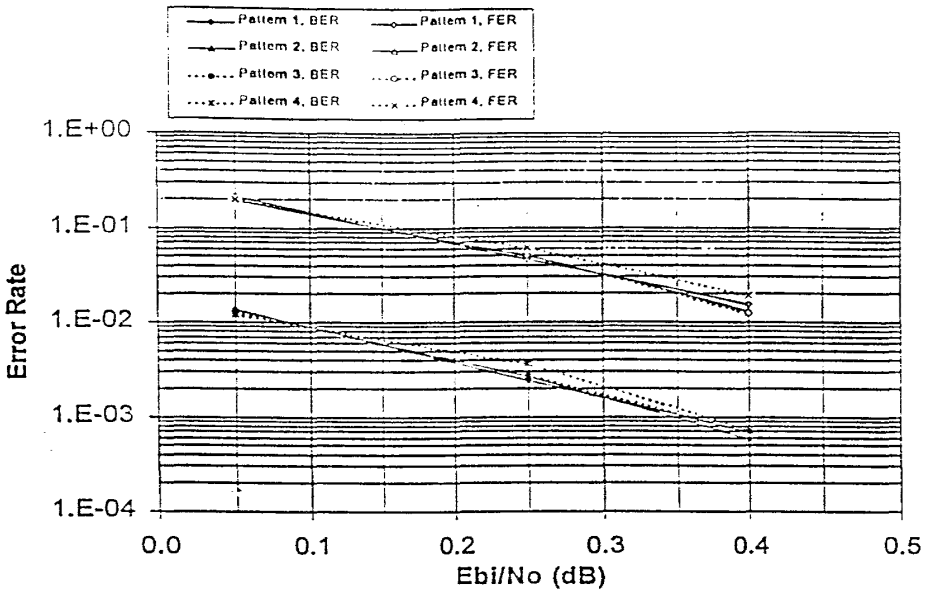
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Appendix Fig. A-21 BER/FER Performance of Code #1, Frame Size=1024

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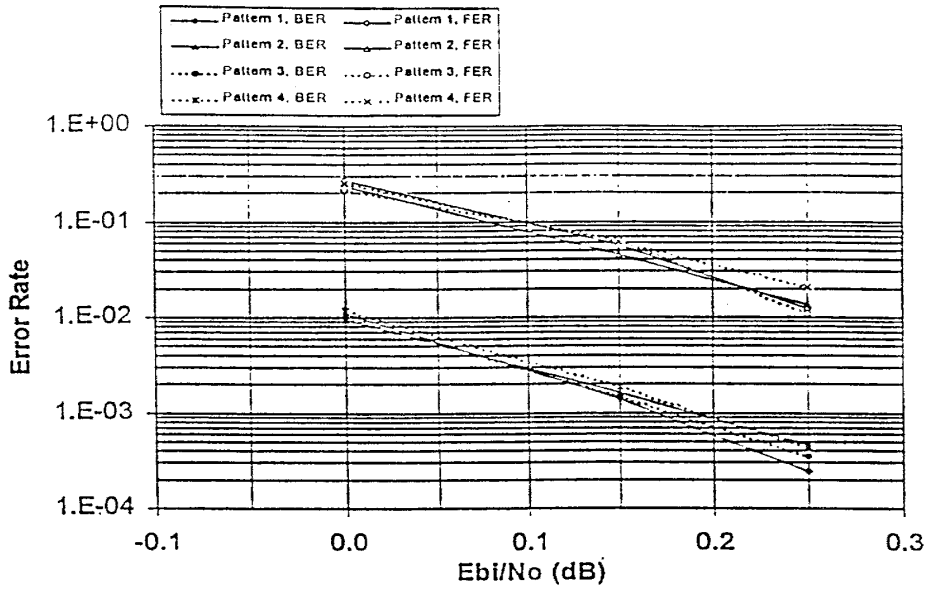
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Appendix Fig. A-22 BER/FER Performance of Code #1, Frame Size=2048

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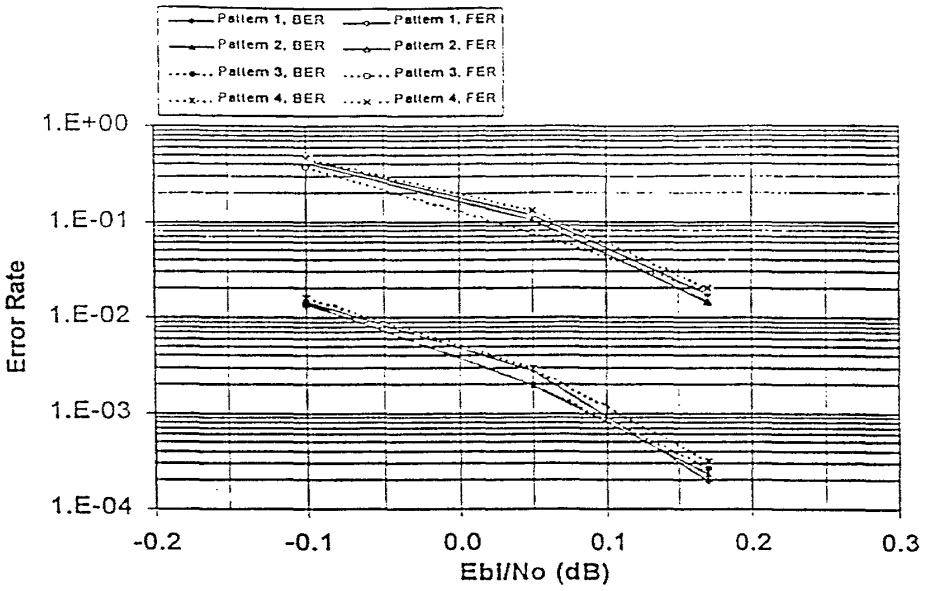
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Appendix Fig. A-23 BER/FER Performance of Code #1, Frame Size=3072

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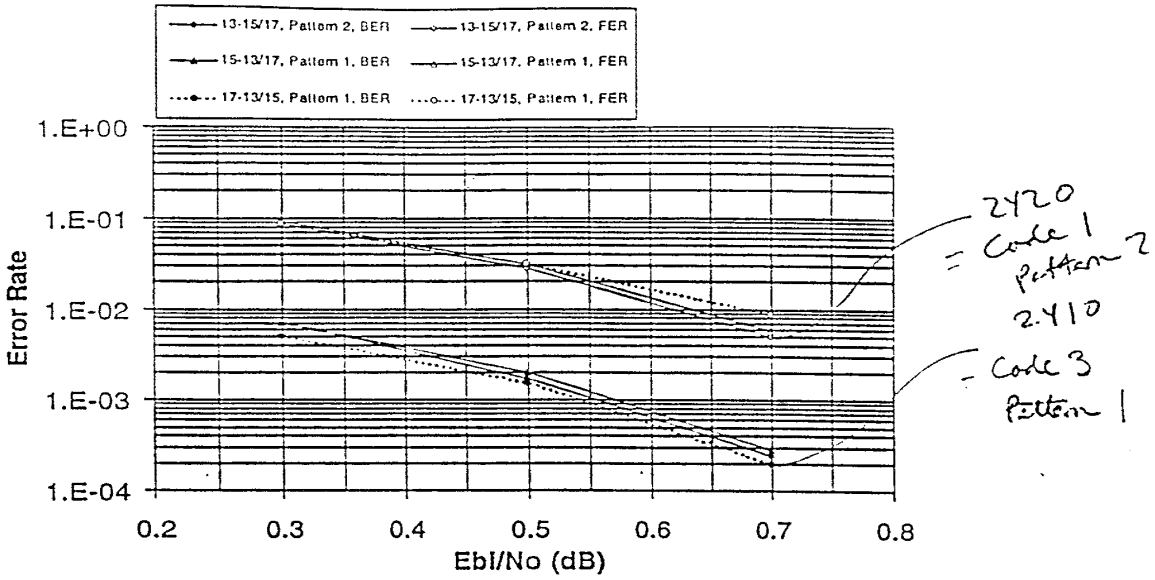
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Appendix Fig. A-24 BER/FER Performance of Selected Rate-1/4 Turbo Codes, Frame Size=512

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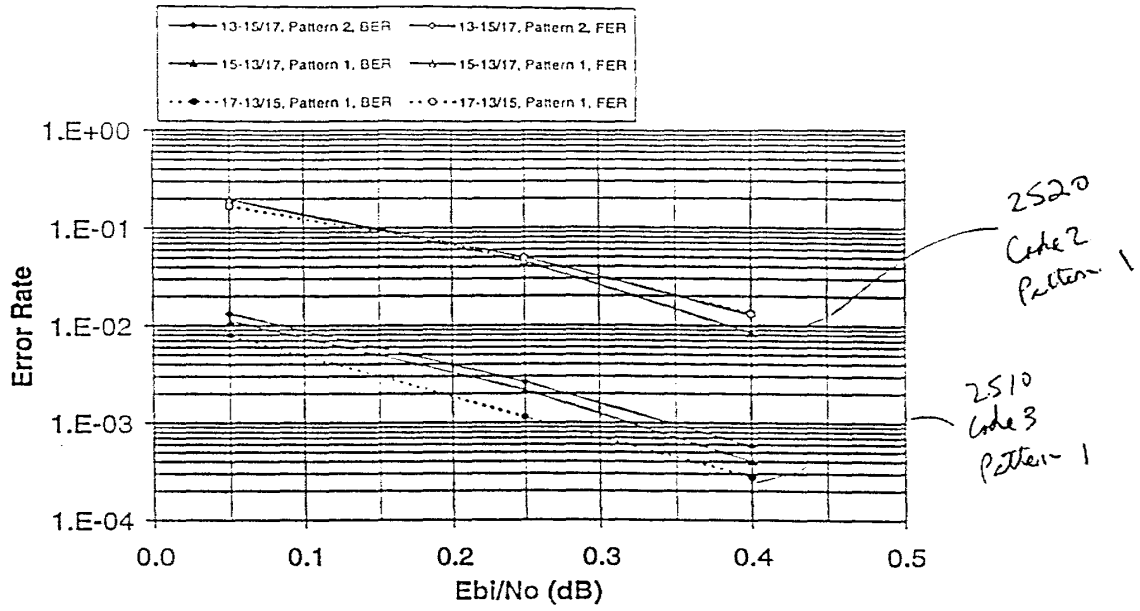
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Appendix Fig. A-25 BER/FER Performance of Selected Rate-1/4 Turbo Codes, Frame Size=1024

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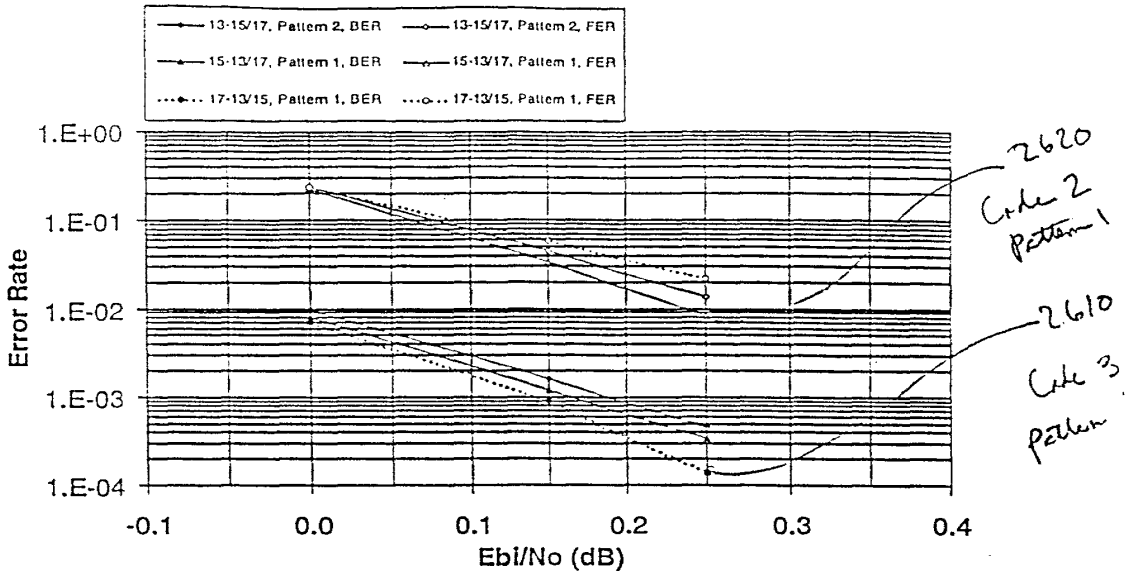
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Appendix Fig. A-26 BER/FER Performance of Selected Rate-1/4 Turbo Codes, Frame Size=2048

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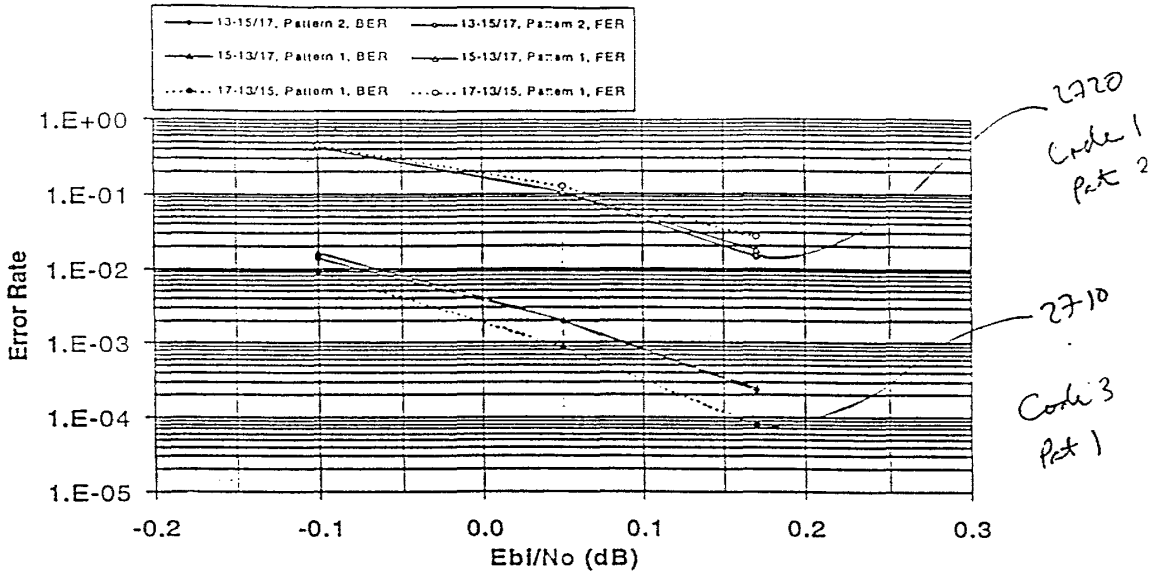
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Appendix Fig. A-27 BER/FER Performance of Selected Rate-1/4 Turbo Codes, Frame Size=3072

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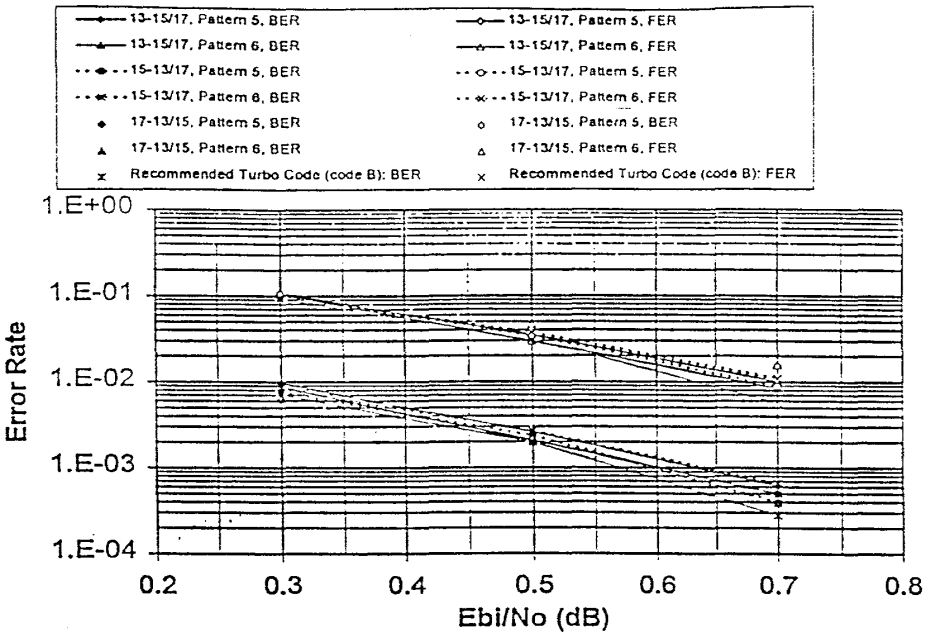
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Appendix Fig. A-28 Comparison against other puncturing schemes, frame= 512.

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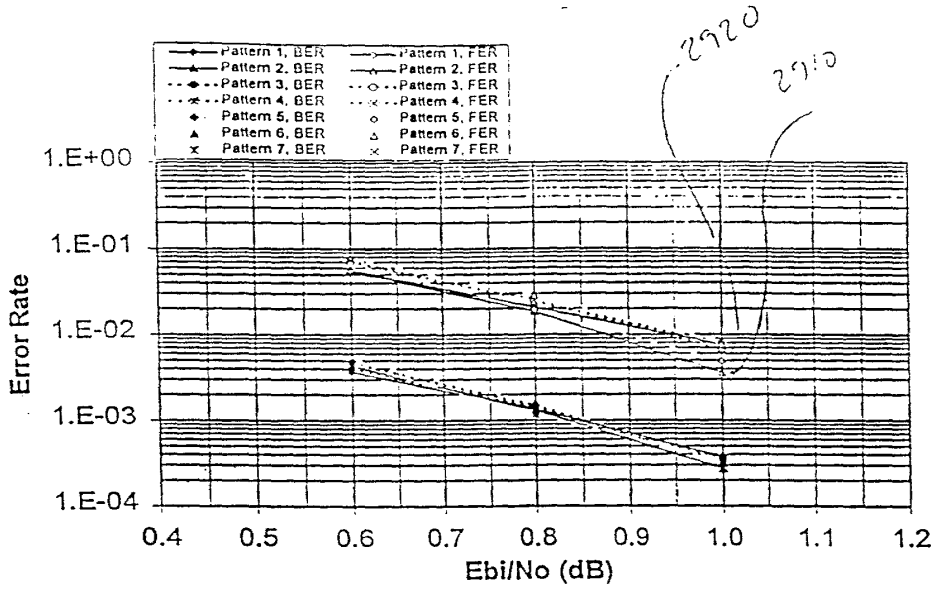
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Appendix Fig. A-29 Comparison of rate 1/3 puncturing schemes, frame = 512

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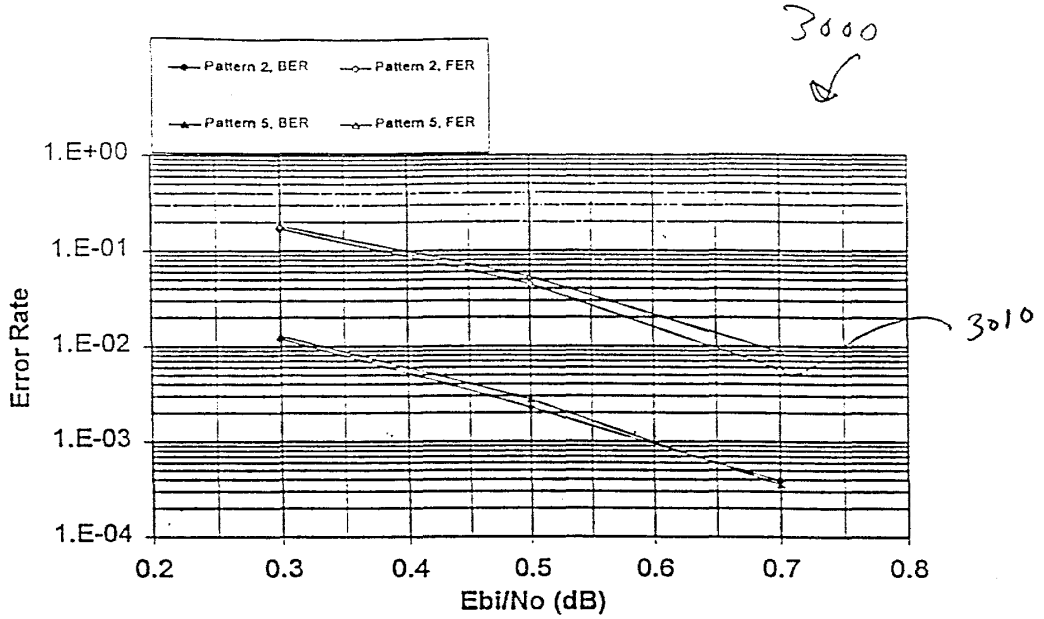
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Appendix Fig. A-30 **Rate 1/3 Puncturing Schemes, frame=1024**

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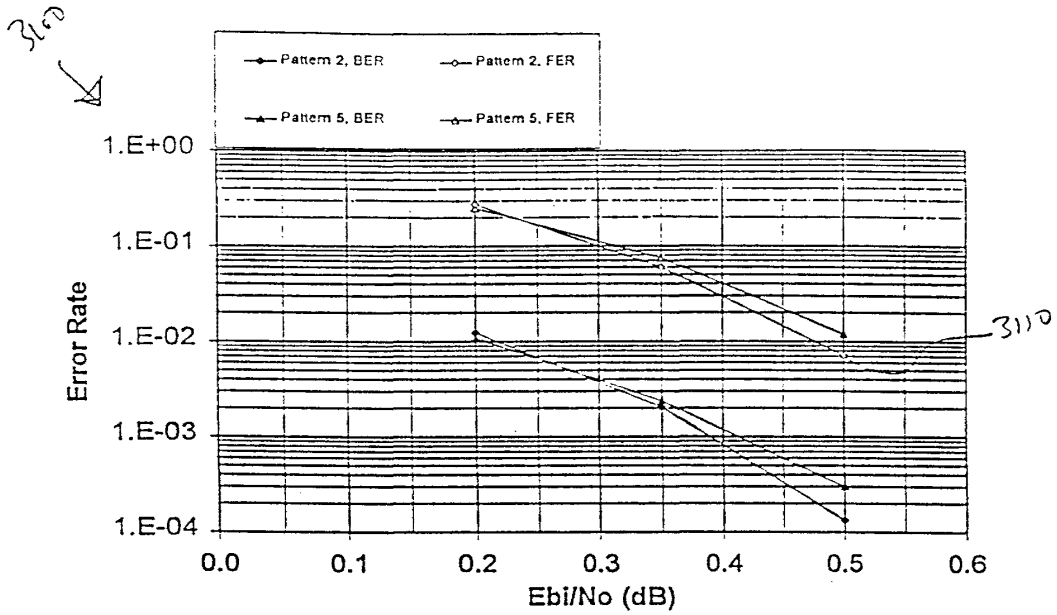
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Appendix Fig. A-31 Rate 1/3 Puncturing Comparison, frame=2048

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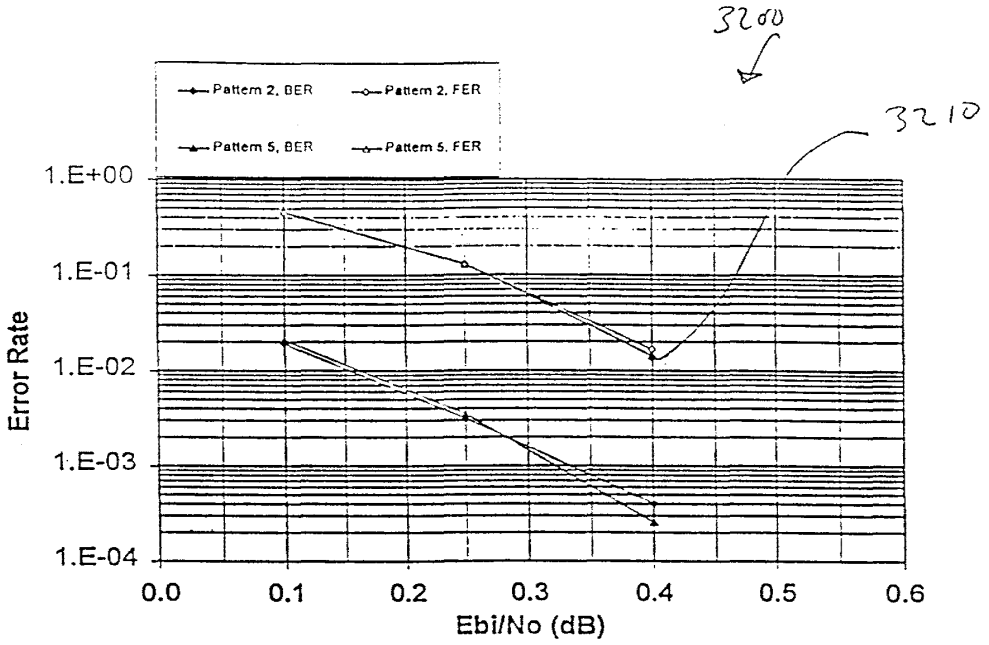
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Appendix Fig. A-32 Rate 1/3 Puncturing Comparison, frame=3072

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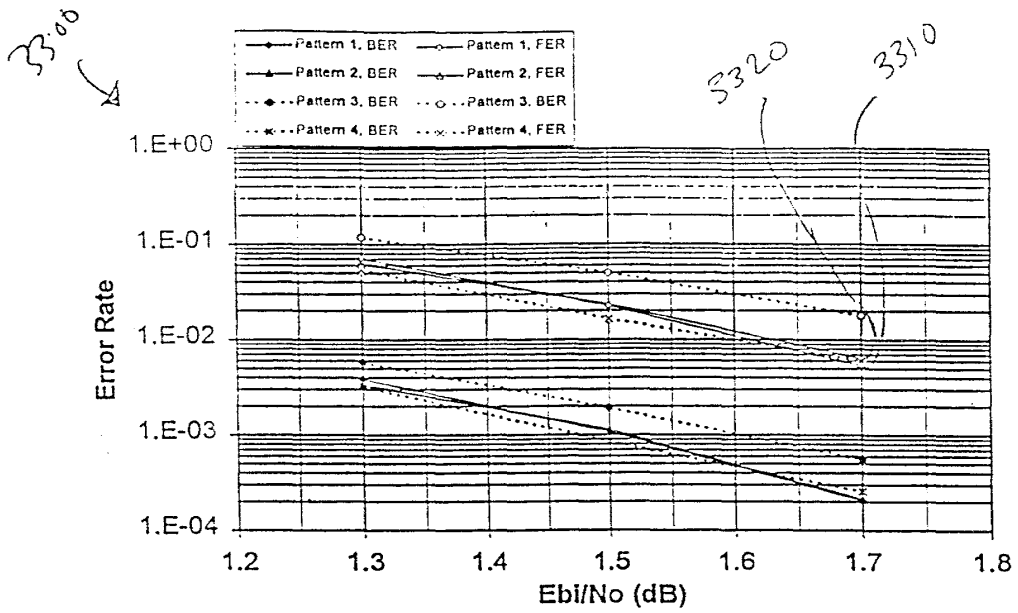
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Appendix Fig. A-33 Rate 1/2 Puncturing Comparison, frame=512

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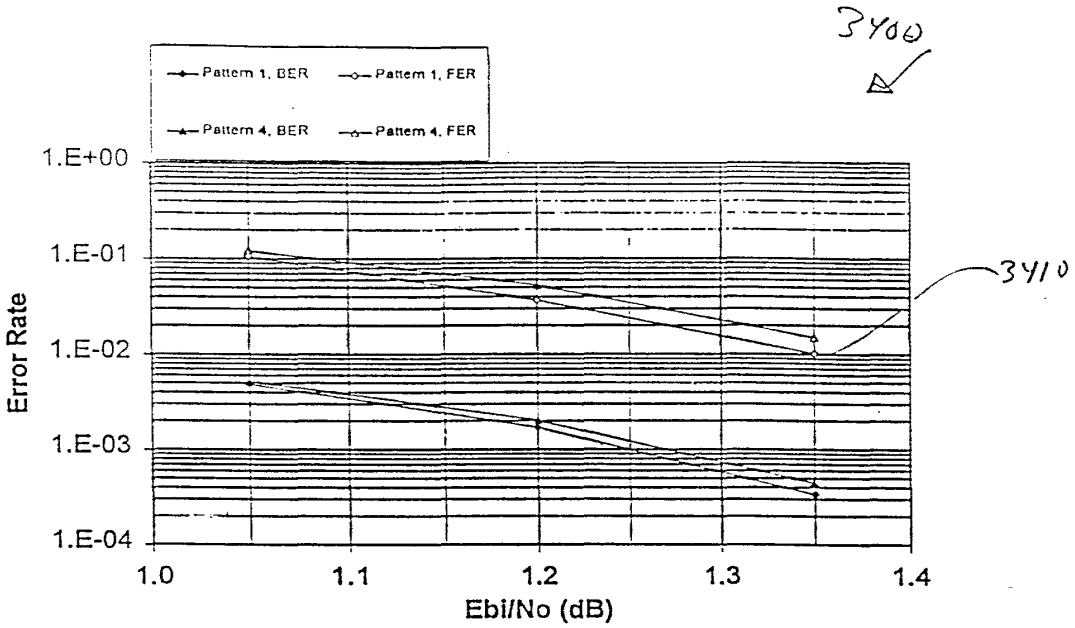
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Appendix Fig. A-34 **Rate 1/2 Puncturing Comparison, frame=1024**

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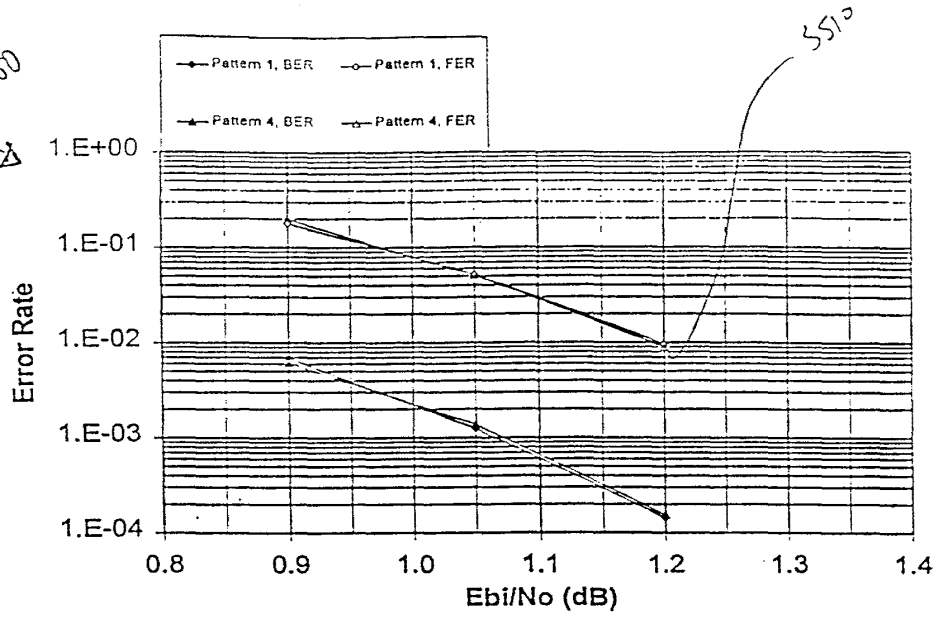
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Appendix Fig. A-35 Rate 1/2 Puncturing Comparison, frame=2048

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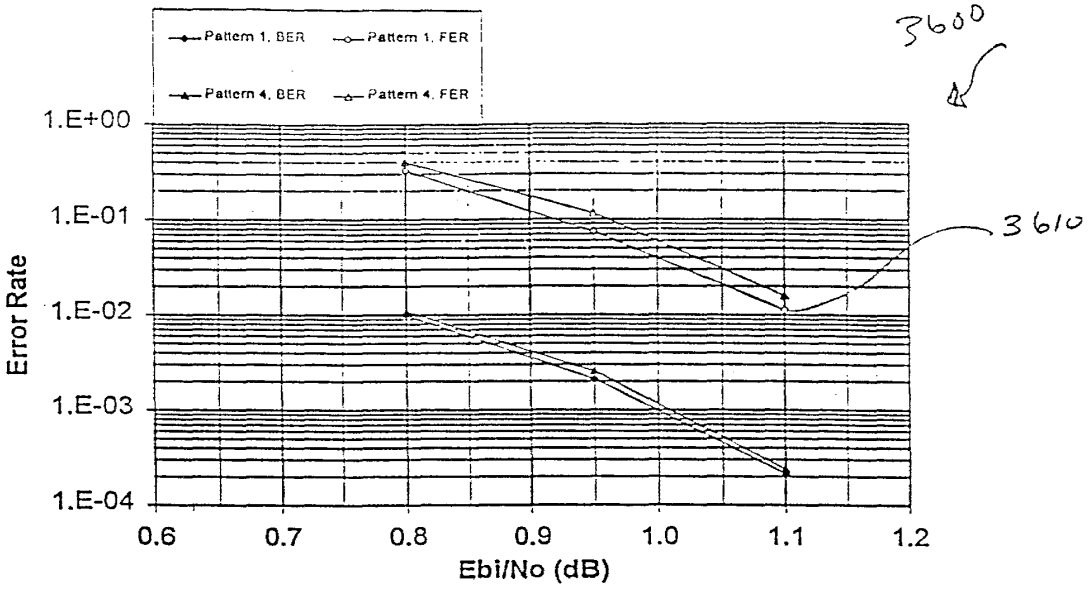
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Appendix Fig. A-36 Rate 1/2 Puncturing Comparison, frame=3072

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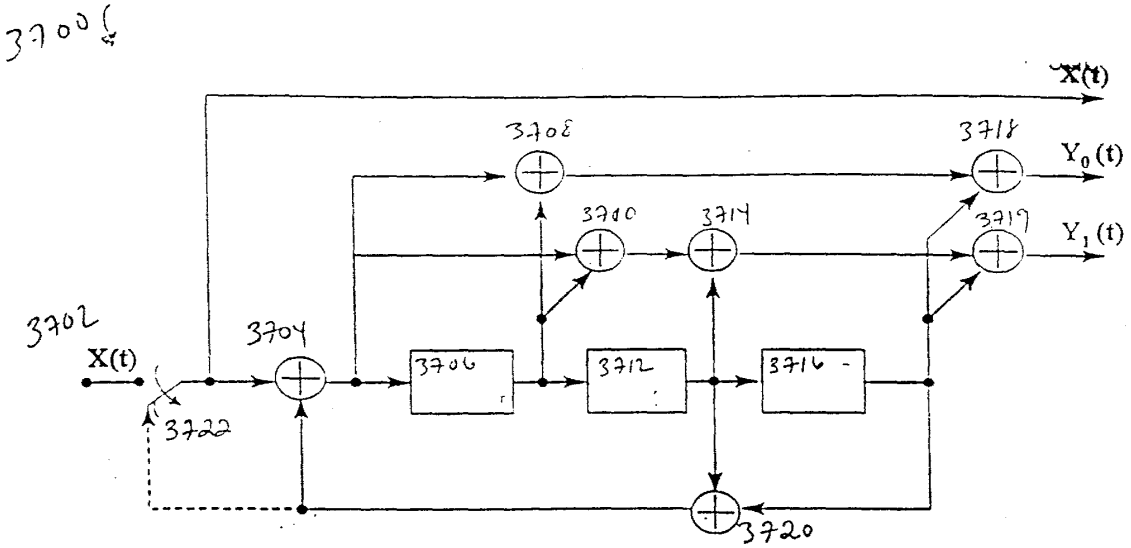
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Appendix Fig. A-37 Universal Constituent Encoder Recommended for Forward Link Turbo Codes of Varying Interleaver Depth

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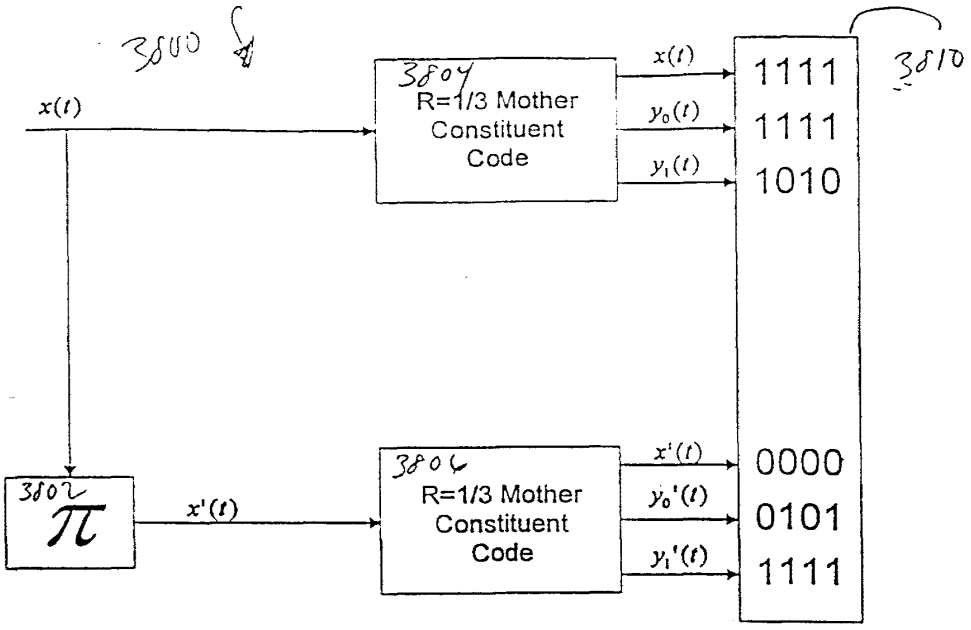
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Appendix Fig. A-38 Forward Link Turbo Code of Rate 1/4 (Mother code in Figure 37)

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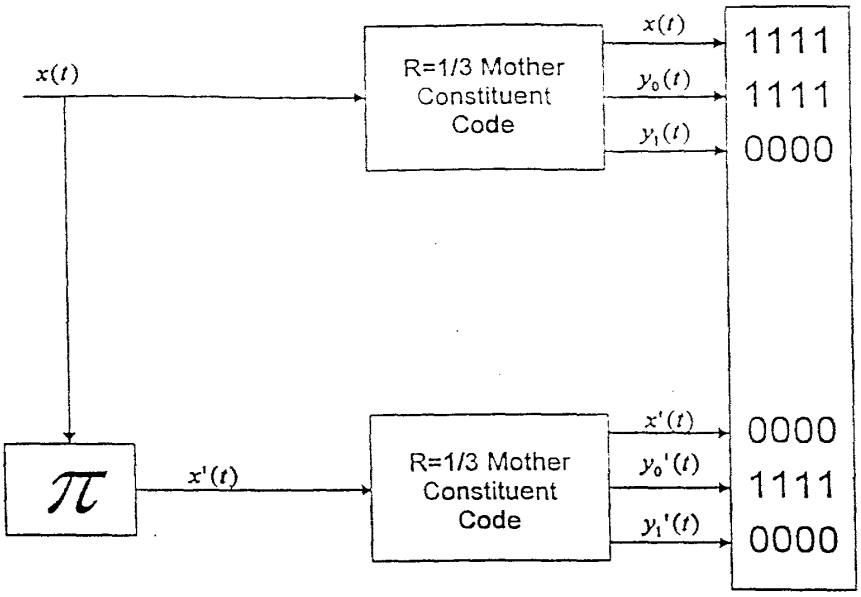
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Appendix Fig. A-39 Forward Link Turbo Code of Rate 1/3 (Mother code in Figure 37)

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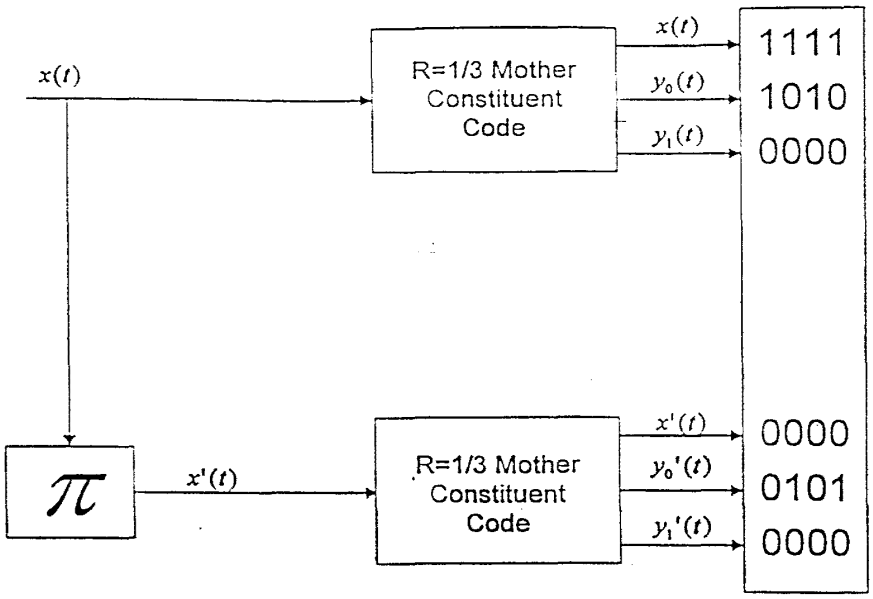
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Appendix Fig. A-40 Forward Link Turbo Code of Rate 1/2 (Mother code in Figure 37)

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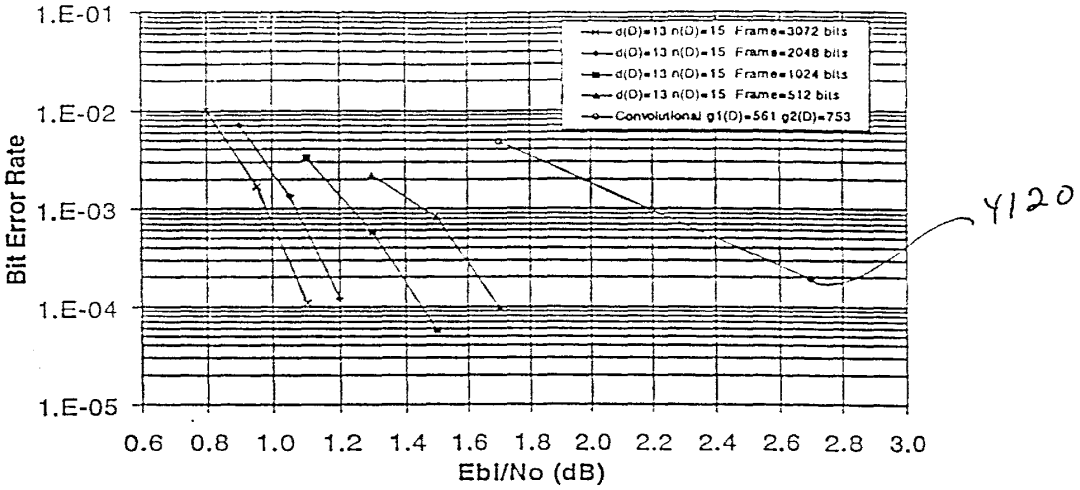
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Appendix Fig. A-41 Comparison of Universal Turbo Code and Optimal Convolutional Code at Rate 1/2

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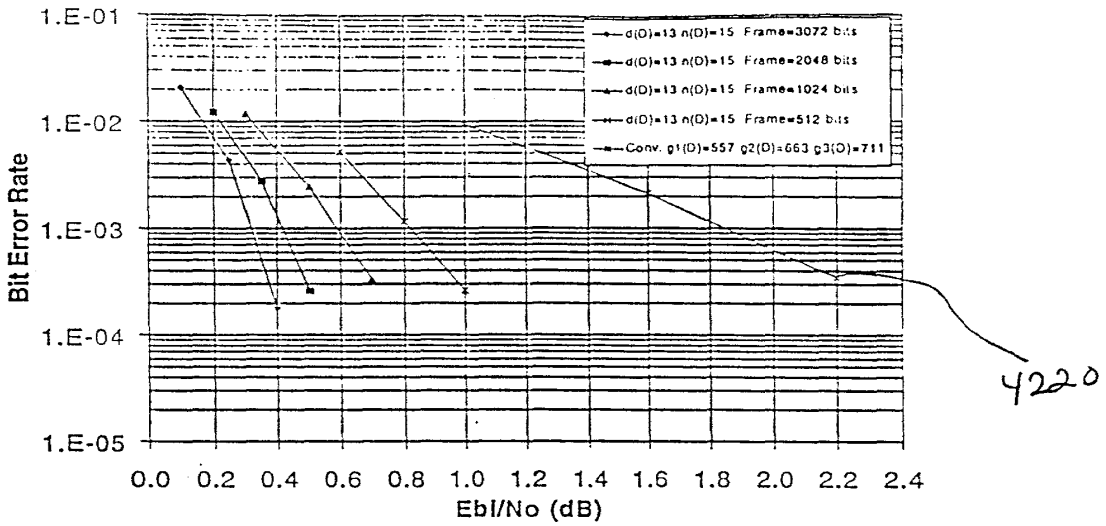
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Appendix Fig. A-42 Comparison of Universal Turbo Code and Optimal Convolutional Code at Rate 1/3

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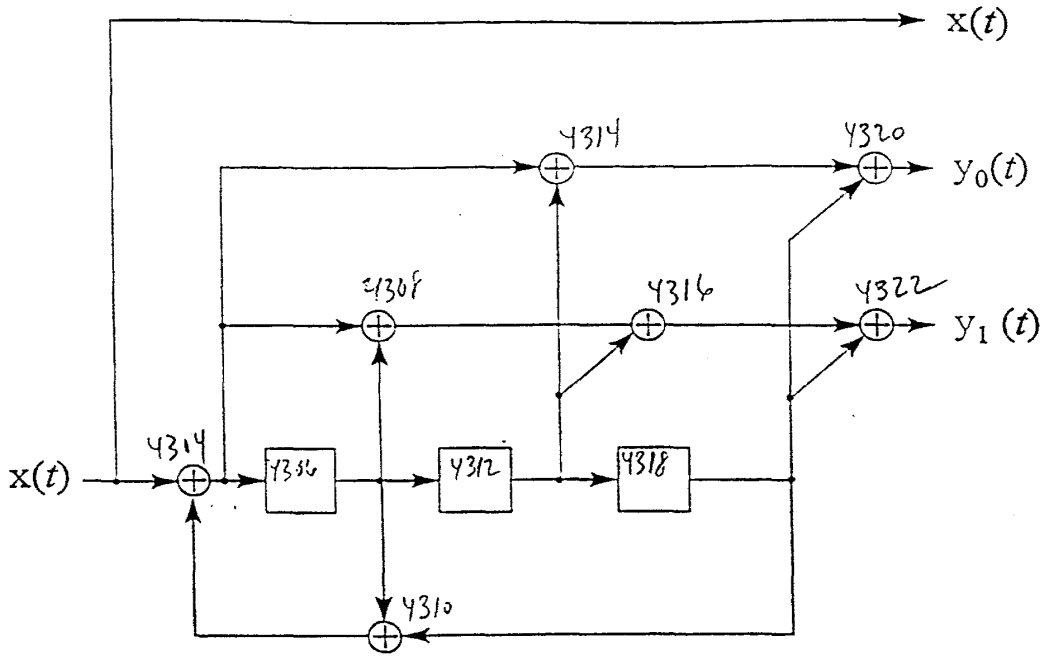
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Appendix Fig. A-43 Constituent Encoder for Reverse-Link Turbo Code

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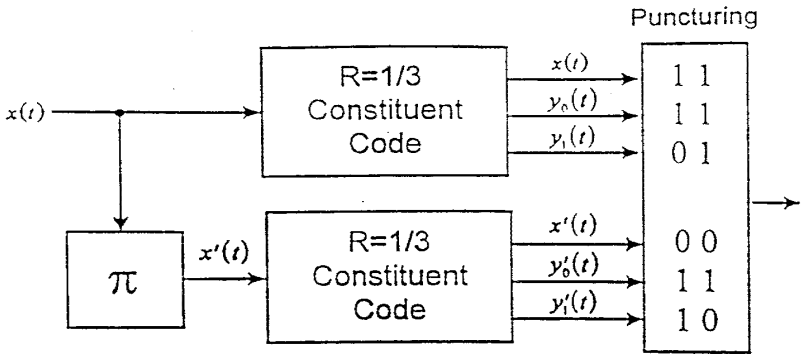
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Appendix Fig. A-44 Reverse-Link Turbo Code of Rate 1/4 (Mother code in Figure 43)

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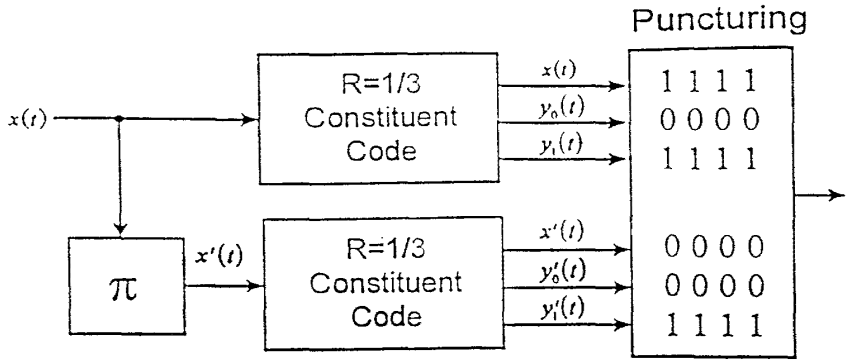
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Appendix Fig. A-45 Reverse Link Turbo Code of Rate 1/3 (Mother code in Figure 43)

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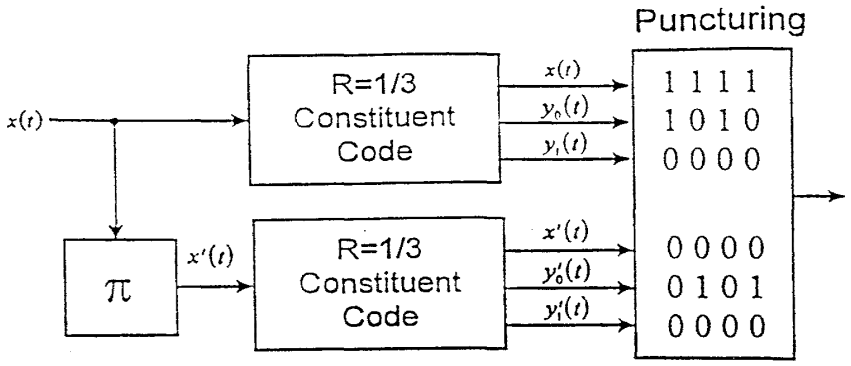
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Appendix Fig. A-46 Reverse Link Turbo Code of Rate ½ (Mother code in Figure 43)

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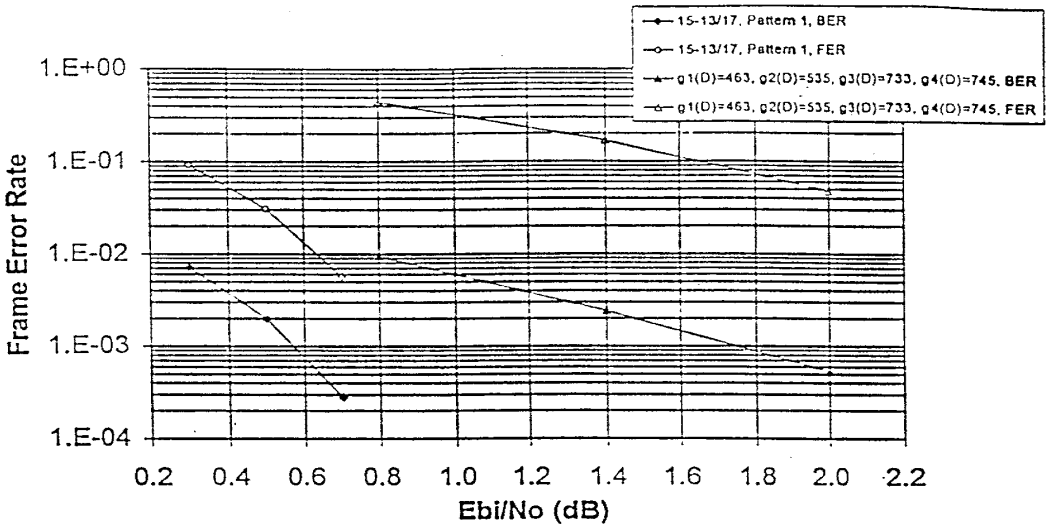
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238 A-1 CS AUG 90 (EACH PAGE UPON WHICH INFORMATION IS ENTERED SHOULD BE SIGNED AND WITNESSED)



Appendix Fig. A-47 Comparison of Rate-1/4 FER-Optimized Turbo Code vs Convolutional Code, Frame Size=512

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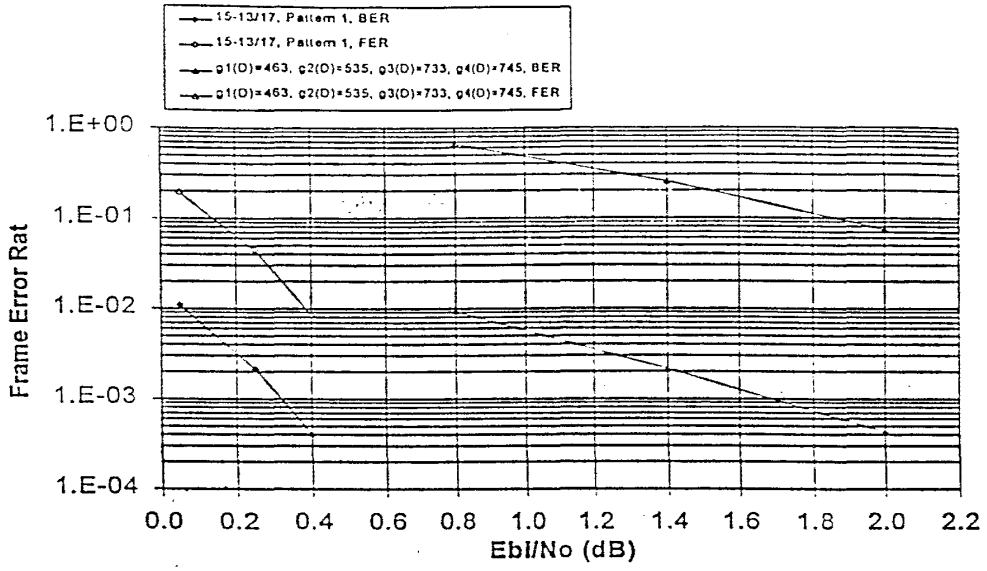
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WITNESS NAME (TYPE) — SIGNATURE — DATE

PATENT DOCKET NO.

236 A-1 CS AUG 90 *(EACH PAGE UPON WHICH INFORMATION IS ENTERED SHOULD BE SIGNED AND WITNESSED)*



Appendix Fig. A-48 **Comparison of Rate-1/4 FER-Optimized Turbo Code vs Convolutional Code, Frame Size=1024**

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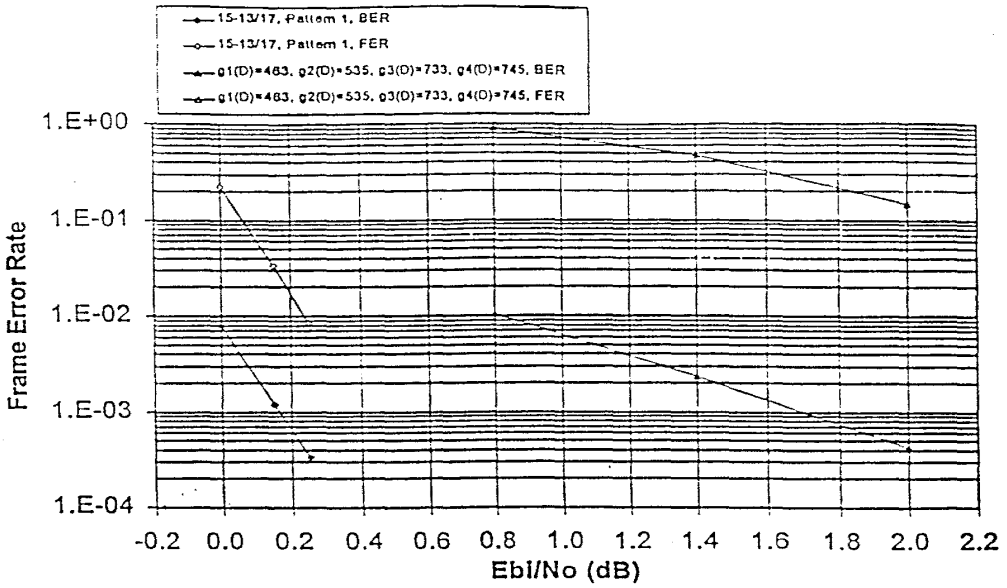
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WITNESS NAME (TYPE) — SIGNATURE — DATE

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Appendix Fig. A-49 Comparison of Rate-1/4 FER-Optimized Turbo Code vs Convolutional Code, Frame Size=2048

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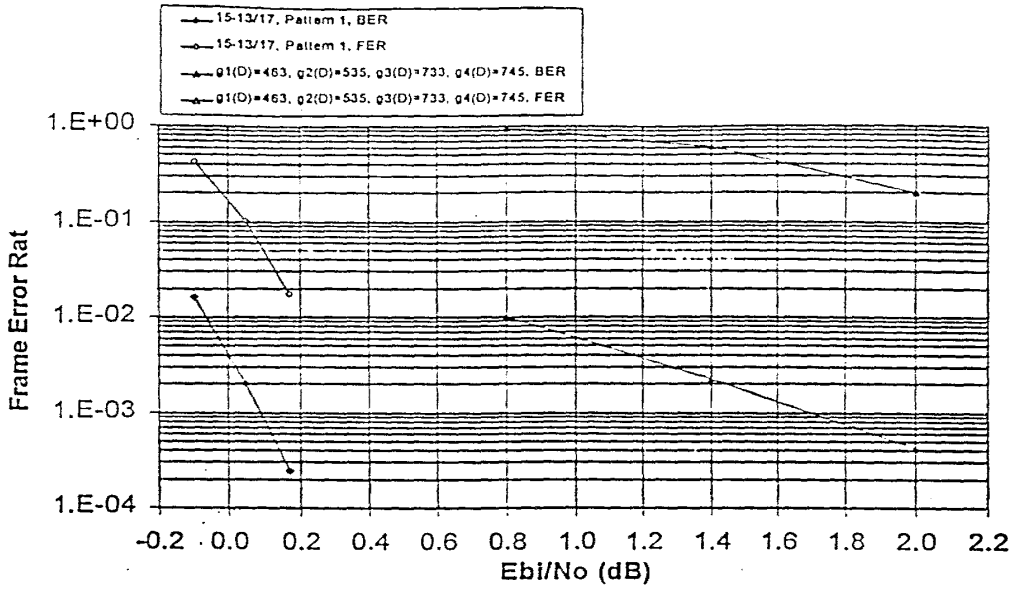
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ɔendix Fig. A-50 Comparison of Rate-1/4 FER-Optimized Turbo Code vs Convolutional Code, Frame Size=3072

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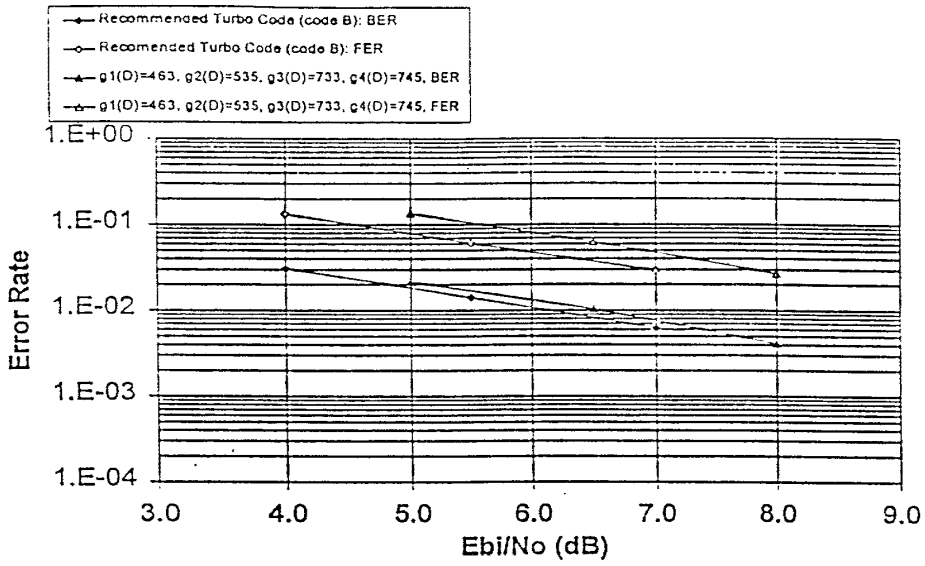
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WITNESS NAME (TYPE) SIGNATURE DATE

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Appendix Fig. A-51 Rayleigh fading channel, 30 mph, frame = 512.

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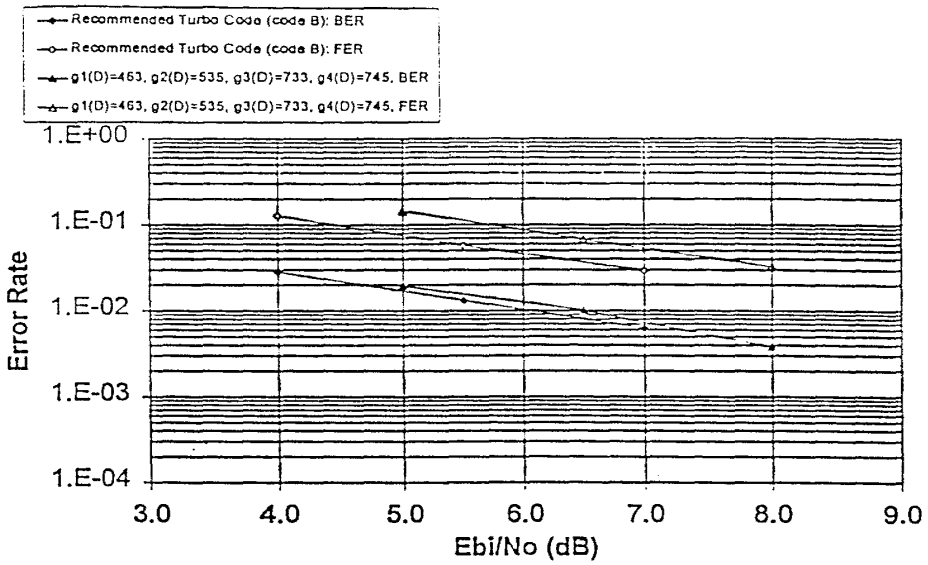
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WITNESS NAME (TYPE) SIGNATURE DATE

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Appendix Fig. A-52 Rayleigh fading, 30 kph, frame = 1024.

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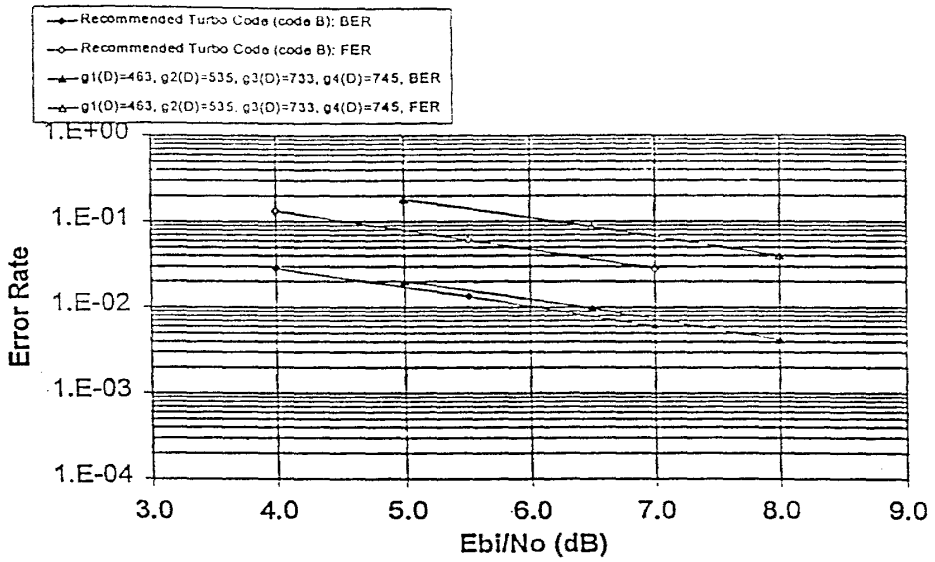
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WITNESS NAME (TYPE) SIGNATURE DATE

WITNESS NAME (TYPE) SIGNATURE DATE

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Appendix Fig. A-53 **Rayleigh, 30 kph, frame = 2048.**

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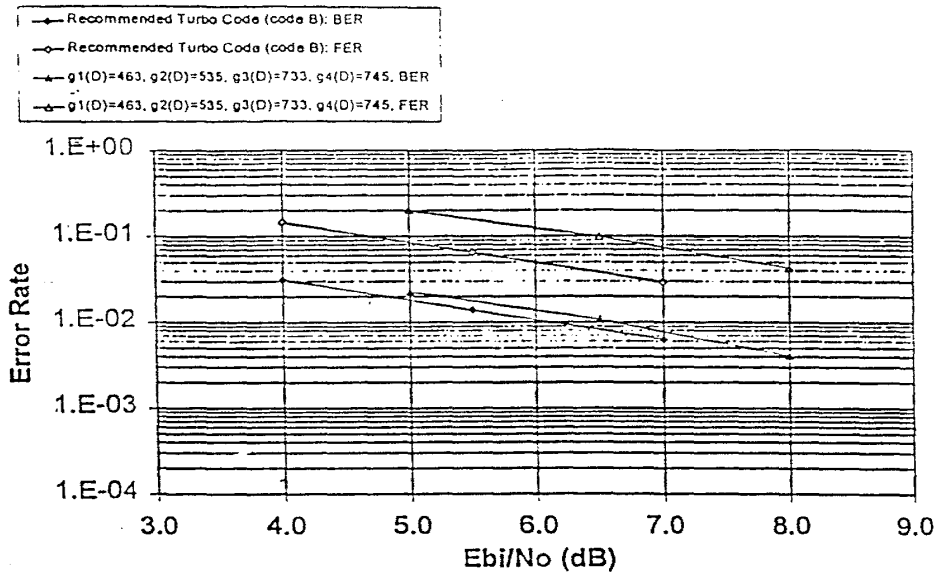
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ppendix Fig. A-54 Rayleigh, 30 kph, frame = 3072.

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WITNESS NAME (TYPE) SIGNATURE DATE

WITNESS NAME (TYPE) SIGNATURE DATE

236 A-1 CS AUG 90 *(EACH PAGE UPON WHICH INFORMATION IS ENTERED SHOULD BE SIGNED AND WITNESSED)*

Pattern 1	Pattern 2
111	111111
111	111110
000	000000
000	000000
110	110111
000	000000

ppendix Fig. A-55 Puncturing patterns for rate 3/8 forward link codes

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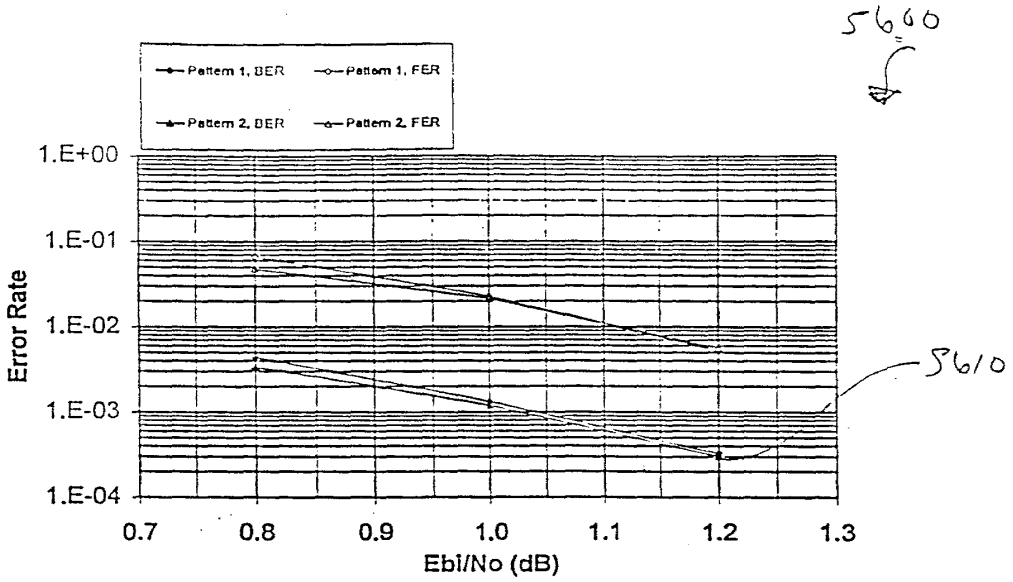
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Appendix Fig. A-56 Rate 3/8 Forward Link Turbo Codes, Frame=512, AWGN channel

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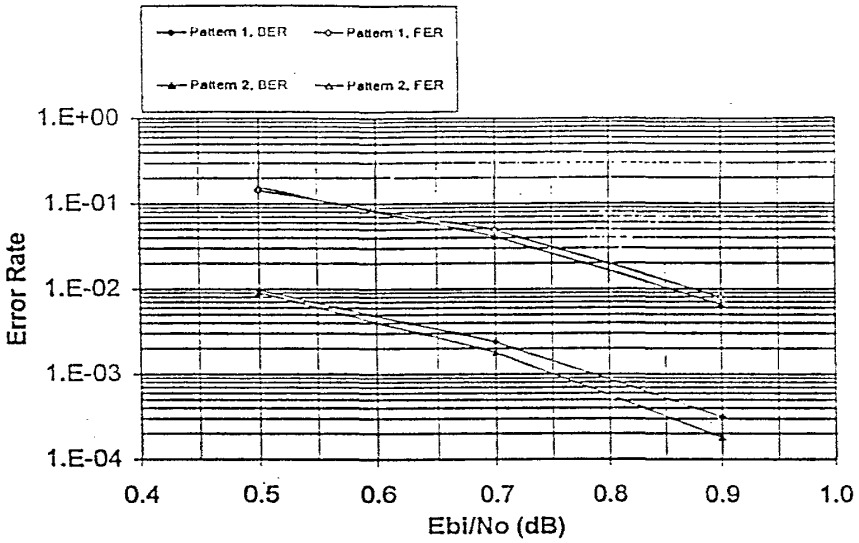
READ AND UNDERSTOOD BY:

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WITNESS NAME (TYPE) SIGNATURE DATE

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.ppendix Fig. A-57 Rate 3/8 Forward Link Turbo Codes, Frame=1024, AWGN channel

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SIGNATURE INVENTOR — DATE 07/22/98

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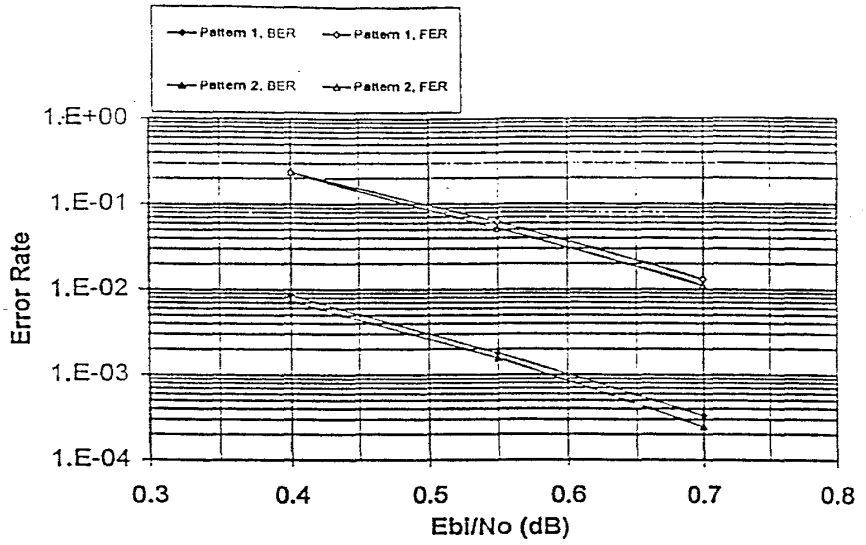
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16 A-1 CS AUG 90 *(EACH PAGE UPON WHICH INFORMATION IS ENTERED SHOULD BE SIGNED AND WITNESSED)*

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Appendix Fig. A-58 **Rate 3/8 Forward Link Turbo Codes, Frame=2048, AWGN channel**

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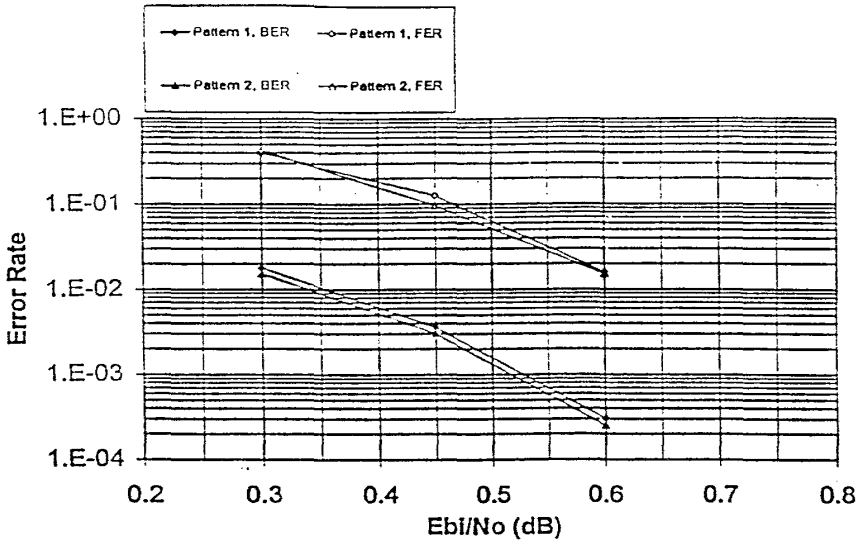
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Appendix Fig. A-59 Rate 3/8 Forward Link Turbo Codes, Frame=3072, AWGN channel

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236 A-1 CS AUG 90 (EACH PAGE UPON WHICH INFORMATION IS ENTERED SHOULD BE SIGNED AND WITNESSED)

PATENT DOCKET NO.

Pattern 1	Pattern 2
1111	11111111
1101	11011010
0000	00000000
0000	00000000
1010	10101101
0000	00000000

ɔendix Fig. A-60 Puncturing patterns for rate 4/9 forward link codes

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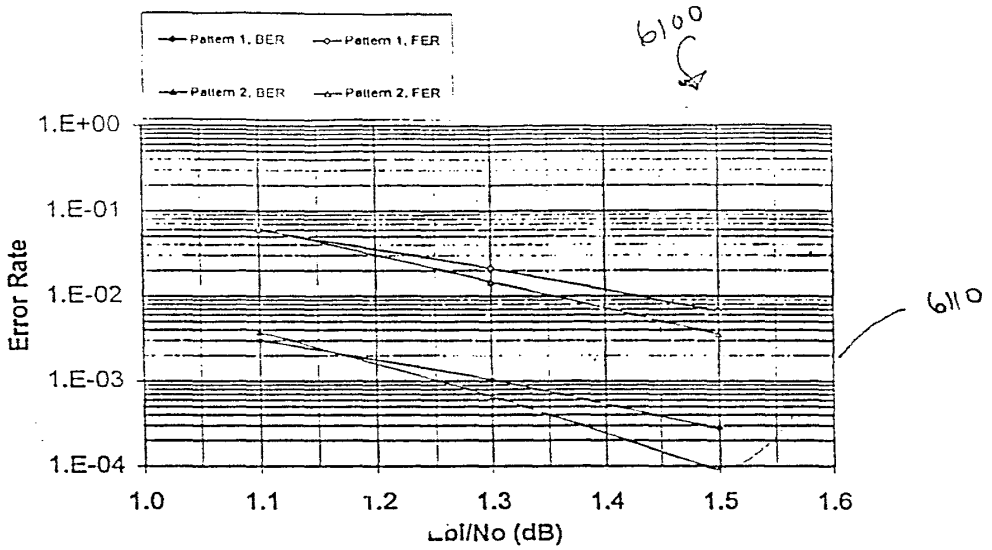
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WITNESS NAME (TYPE) SIGNATURE DATE

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Appendix Fig. A-61 Rate 4/9 Forward Link Turbo Codes, Frame=512, AWGN channel

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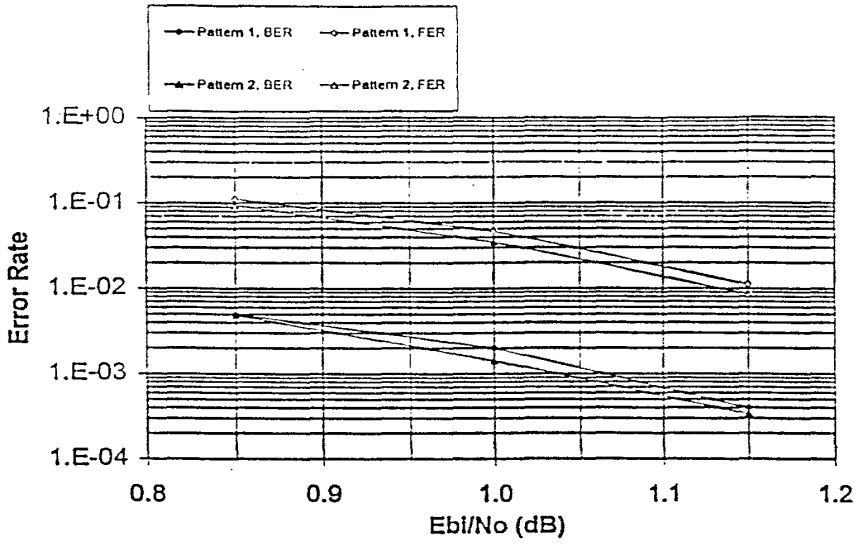
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Appendix Fig. A-62 Rate 4/9 Forward Link Turbo Codes, Frame=1024, AWGN channel

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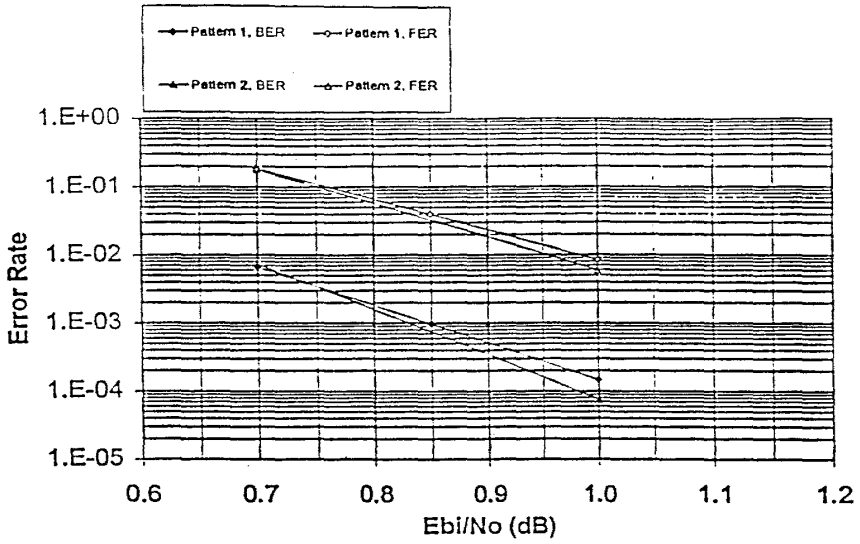
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WITNESS NAME (TYPE) SIGNATURE DATE

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Appendix Fig. A-63 Rate 4/9 Forward Link Turbo Codes, Frame=2048, AWGN channel

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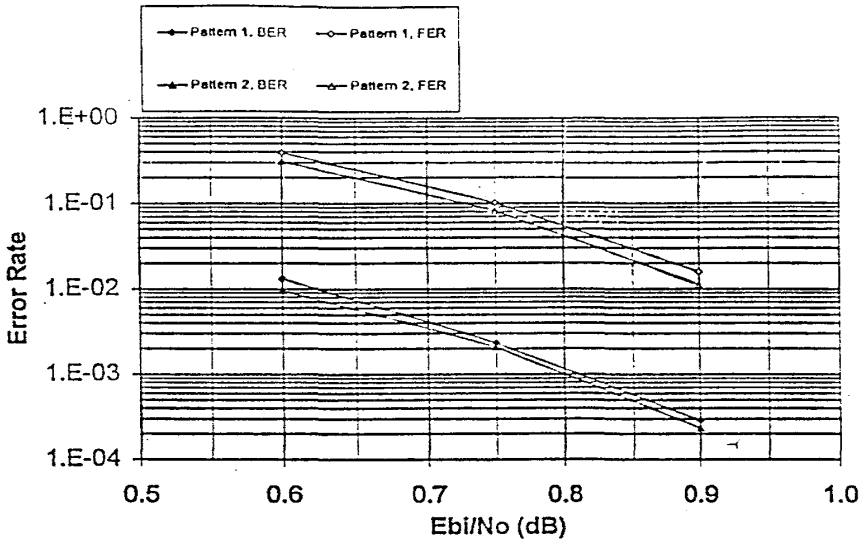
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Appendix Fig. A-64 Rate 4/9 Forward Link Turbo Codes, Frame=3072, AWGN channel

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236 A-1 CS AUG 90 *(EACH PAGE UPON WHICH INFORMATION IS ENTERED SHOULD BE SIGNED AND WITNESSED)*

PATENT DOCKET NO.

Pattern 1	Pattern 2	Pattern 3
1111	1111	1111
1111	1011	1111
1011	1111	1011
0000	0000	0000
1111	1110	1110
1110	1111	1111

Appendix Fig. A-65 Puncturing patterns for rate 2/9 reverse link codes

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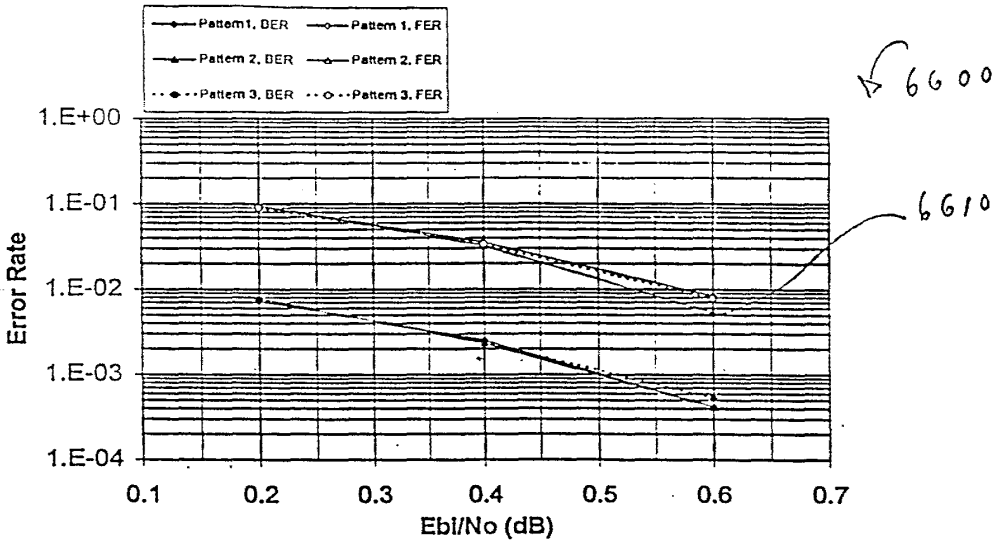
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Appendix Fig. A-66 **Rate 2/9 Reverse Link Turbo Codes, Frame=512, AWGN channel**

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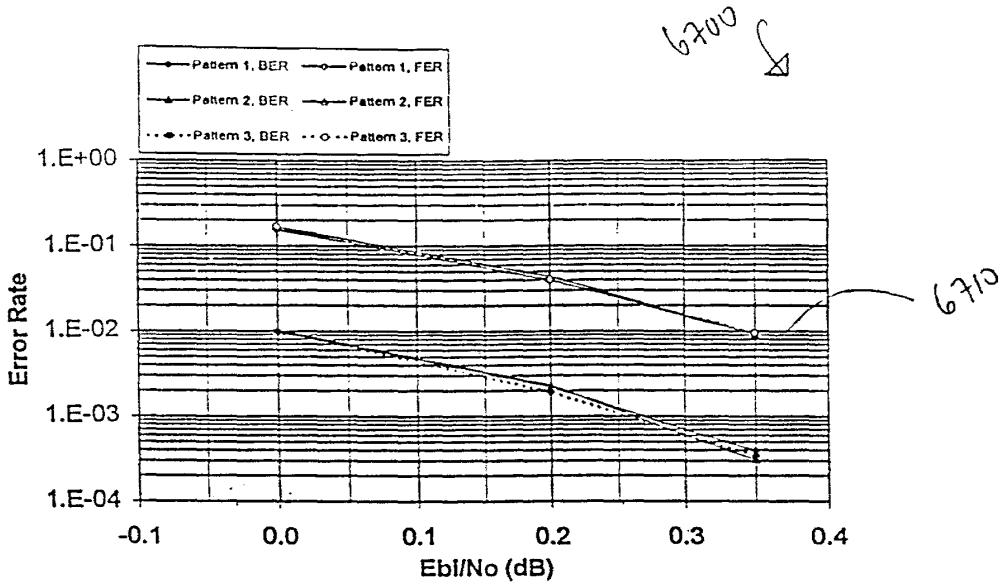
READ AND UNDERSTOOD BY:

WITNESS NAME (TYPE) — SIGNATURE — DATE

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Appendix Fig. A-67 Rate 2/9 Reverse Link Turbo Codes, Frame=1024, AWGN channel

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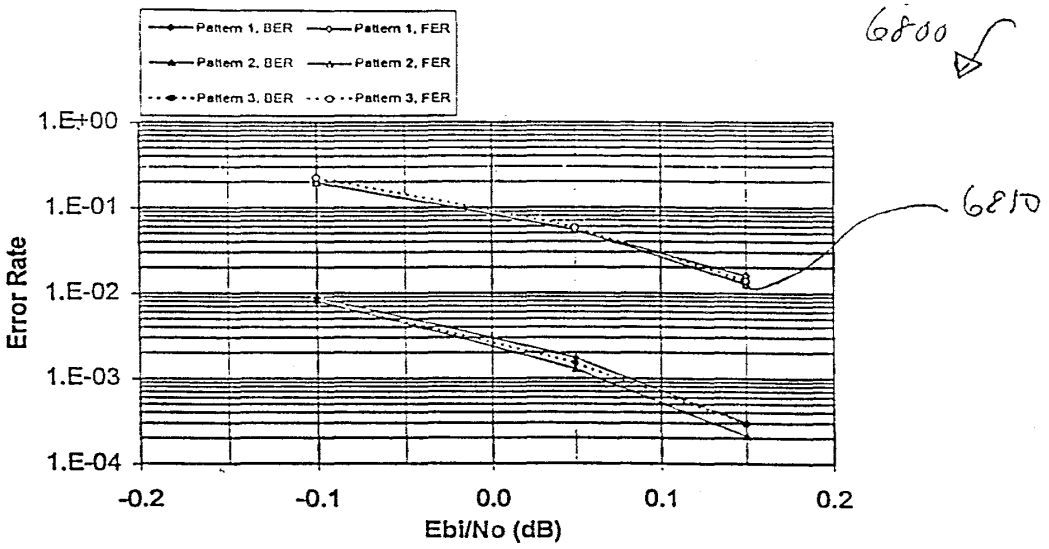
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Appendix Fig. A-68 Rate 2/9 Reverse Link Turbo Codes, Frame=2048, AWGN channel

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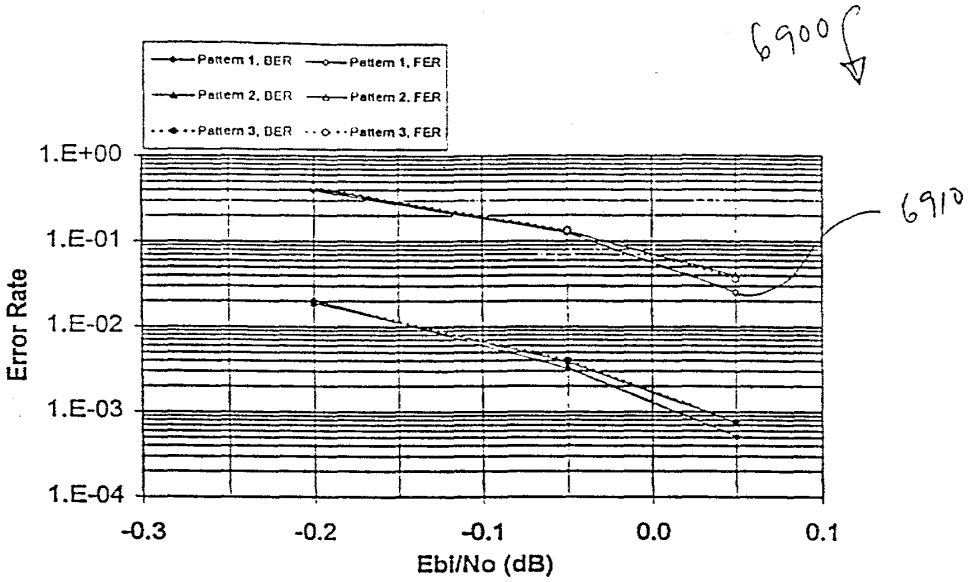
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Appendix Fig. A-69 Rate 2/9 Reverse Link Turbo Codes, Frame=3072, AWGN channel

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Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5	Pattern 6
111	111	111	111	111	111
111	110	110	100	100	000
000	001	001	011	011	111
000	000	000	000	000	000
110	110	010	010	000	000
000	000	100	100	110	110

Appendix Fig. A-70 Initial puncturing patterns for rate 3/8 reverse link codes

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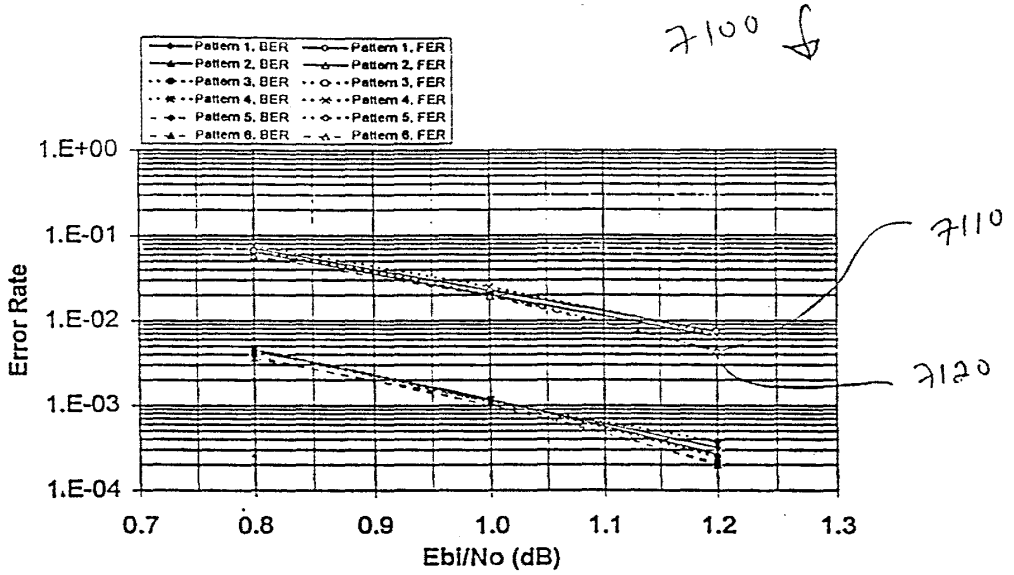
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ıdix Fig. A-71 Rate 3/8 Reverse Link Turbo Codes, Frame=512, AWGN channel (Initial Screening)

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Pattern 5	Pattern 6	Pattern 7	Pattern 8
111	111	111111	111111
100	000	100000	000000
011	111	011011	111110
000	000	000000	000000
000	000	000100	000000
110	110	110110	110111

Appendix Fig. A-72 Puncturing patterns for rate 3/8 reverse link codes

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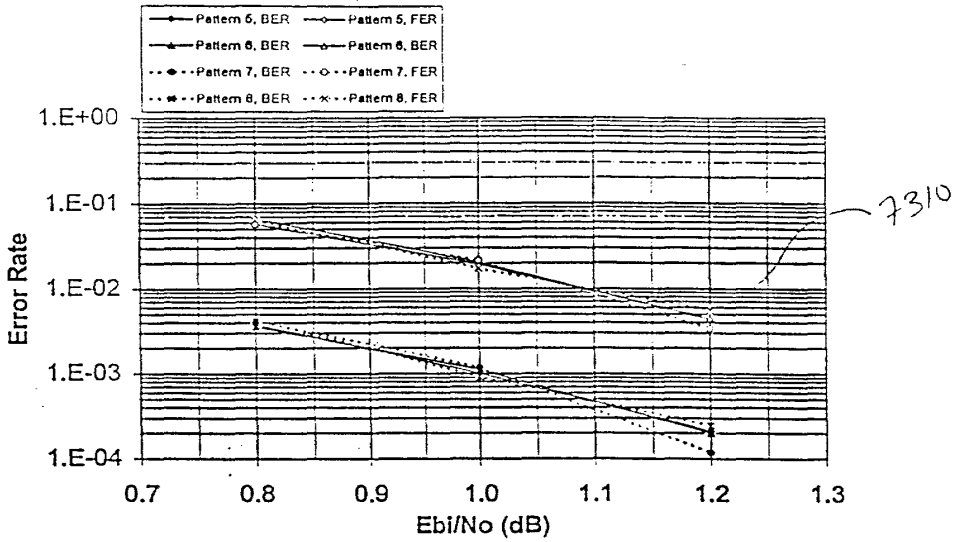
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Appendix Fig. A-73 Rate 3/8 Reverse Link Turbo Codes, Frame=512, AWGN channel

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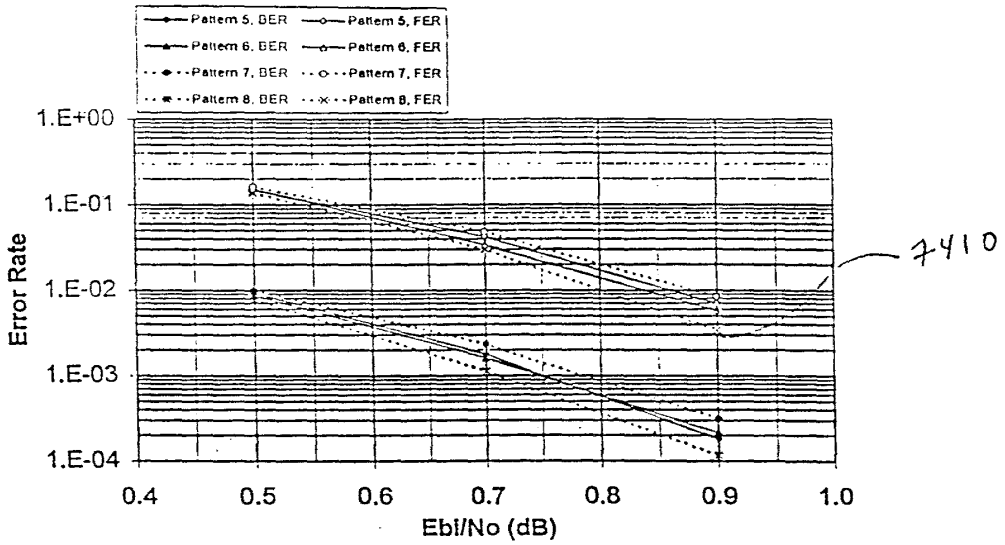
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Appendix Fig. A-74 Rate 3/8 Reverse Link Turbo Codes, Frame=1024, AWGN channel

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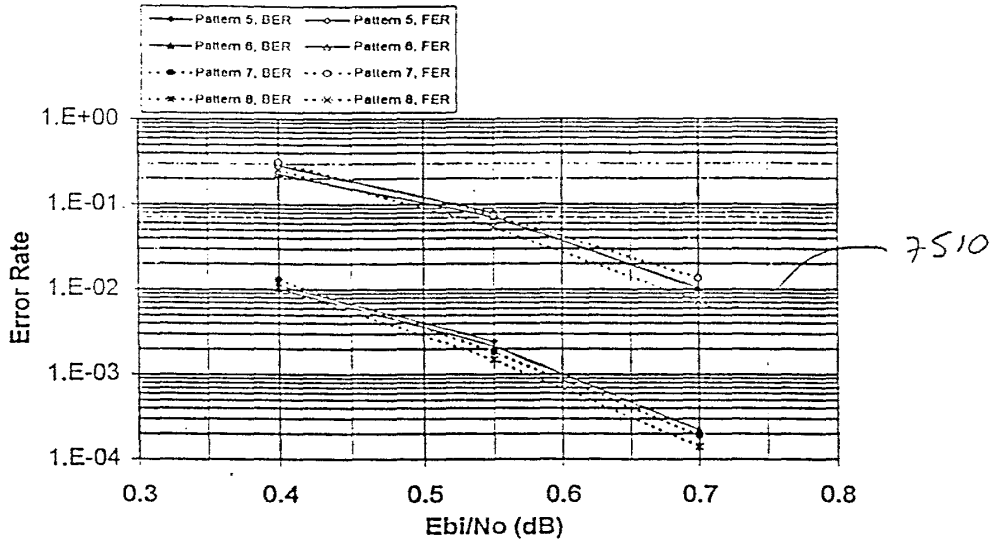
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Appendix Fig. A-75 Rate 3/8 Reverse Link Turbo Codes, Frame=2048, AWGN channel

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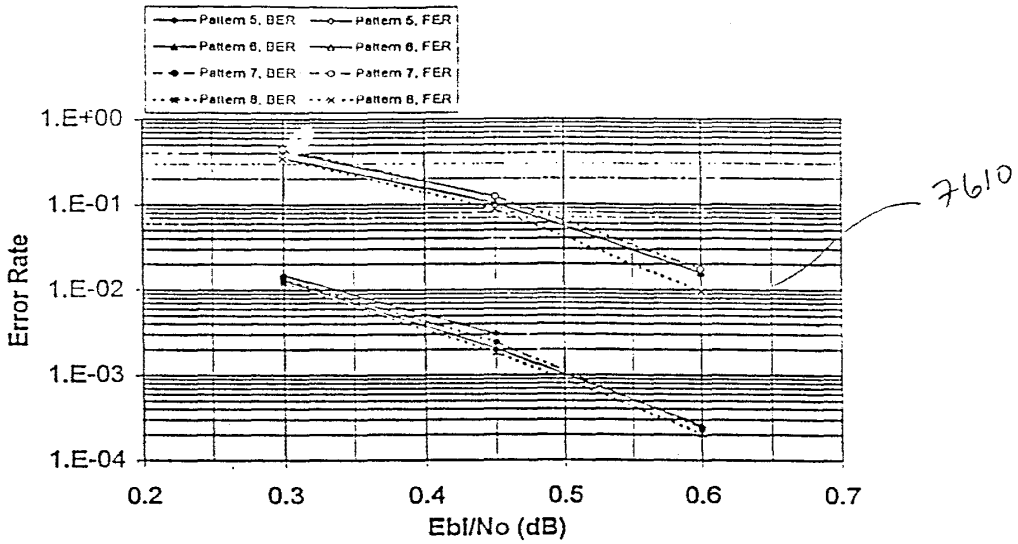
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Appendix Fig. A-76 Rate 3/8 Reverse Link Turbo Codes, Frame=3072, AWGN channel

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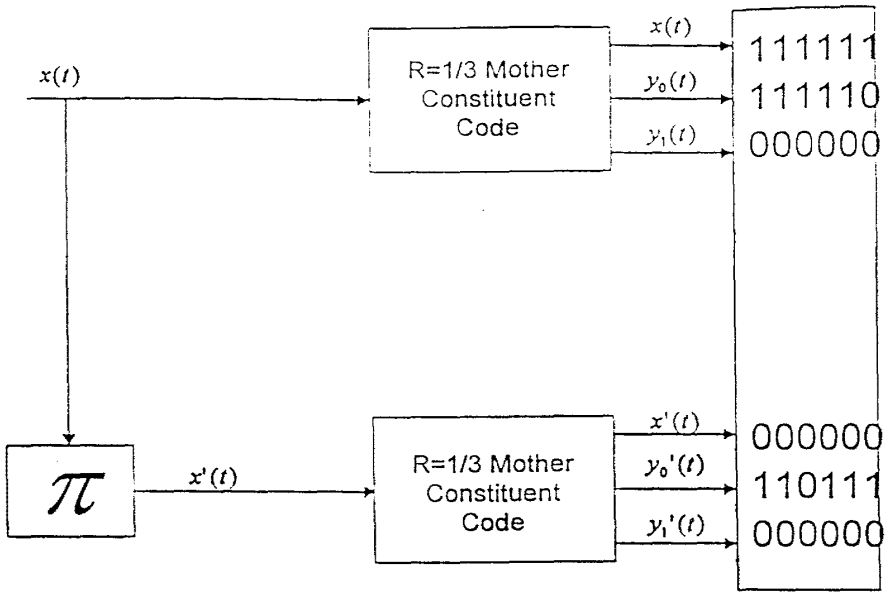
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Appendix Fig. A-77 Forward Link Turbo Code of Rate 3/8 (Mother code in Figure 38)

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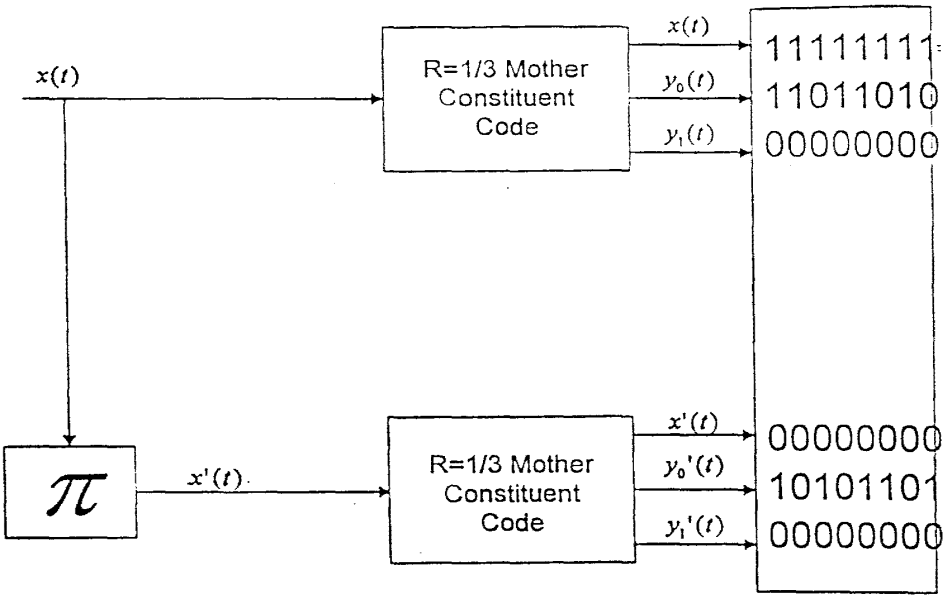
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Appendix Fig. A-78 **Forward Link Turbo Code of Rate 4/9 (Mother code in Figure 38**

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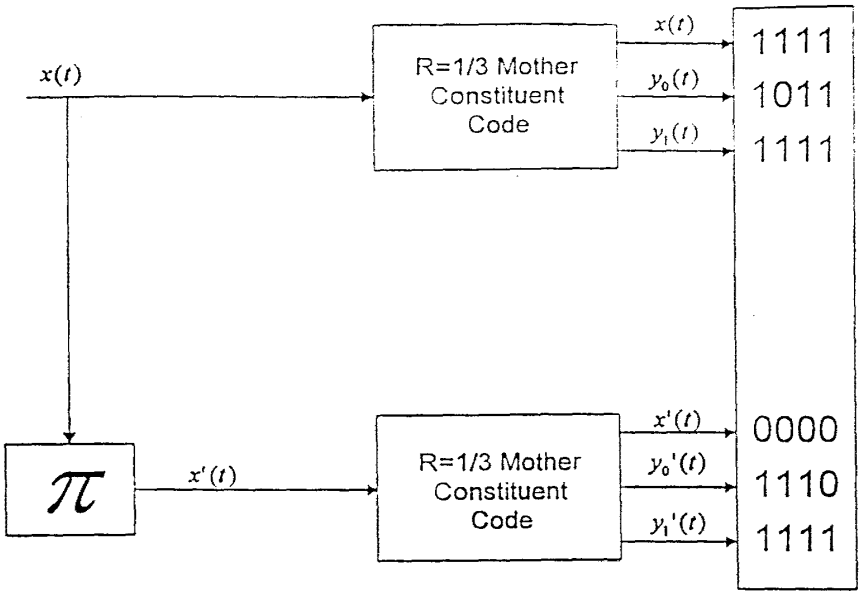
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Appendix Fig. A-79 Reverse Link Turbo Code of Rate 2/9 (Mother code in Figure 43

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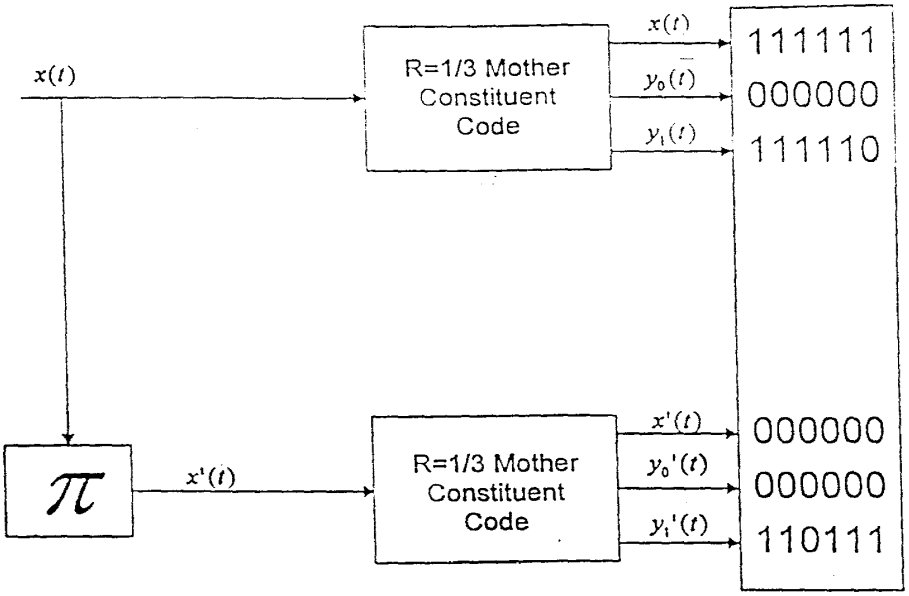
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Appendix Fig. A-80 Reverse Link Turbo Code of Rate 3/8 (Mother code in Figure 43

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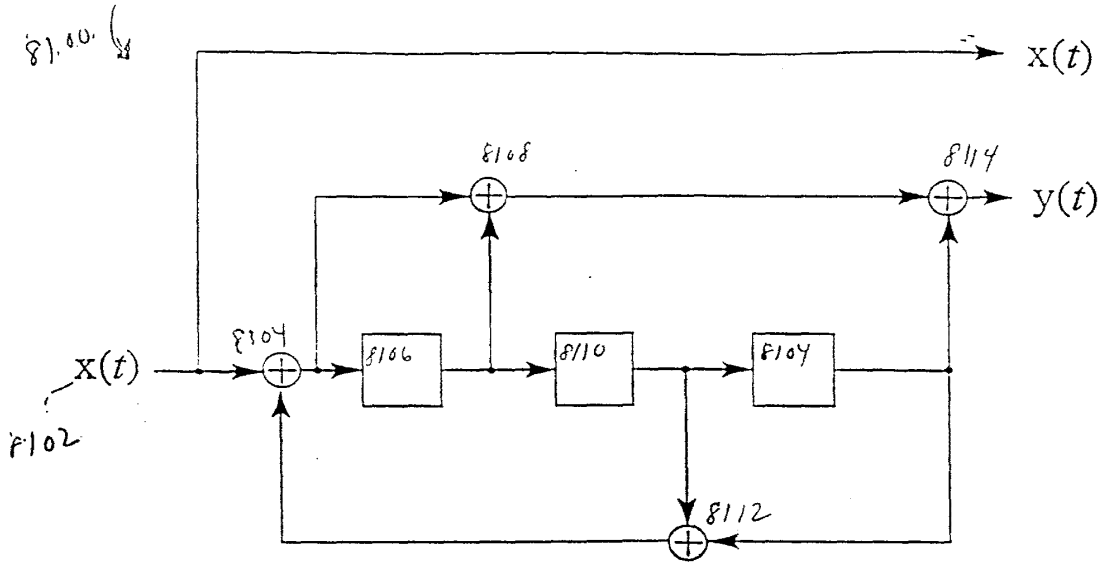
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Appendix Fig. A-81 Universal Constituent Encoder Recommended for R=1/2 and R=1/3 Turbo Codes of Varying Interleaver Depth

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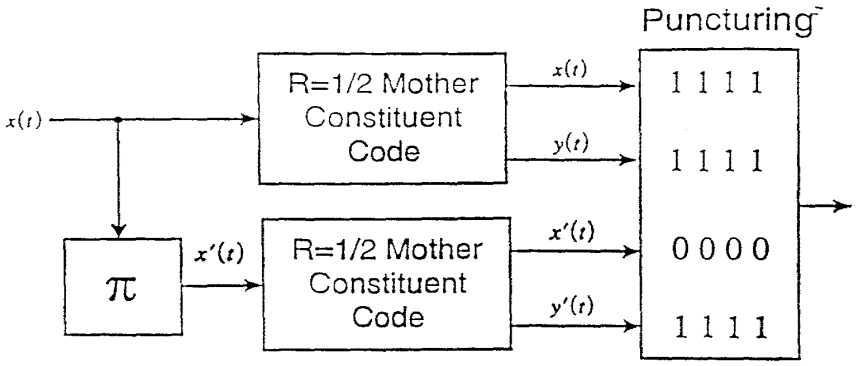
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Appendix Fig. A-82 Rate-Compatible Turbo Code of Rate 1/3

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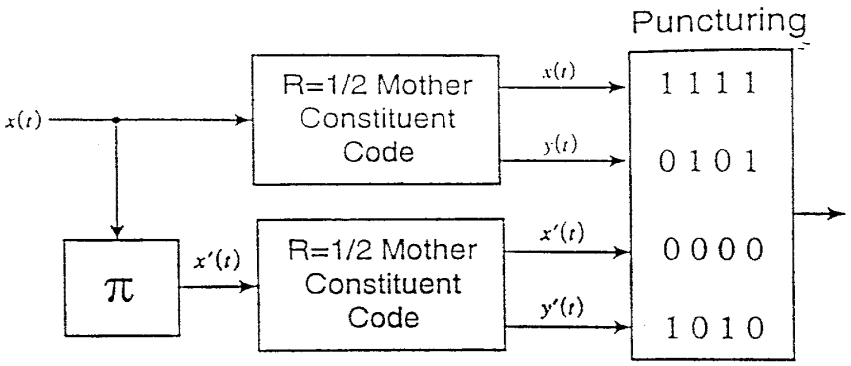
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Appendix Fig. A-83 Rate-Compatible Turbo Code of Rate 1/2

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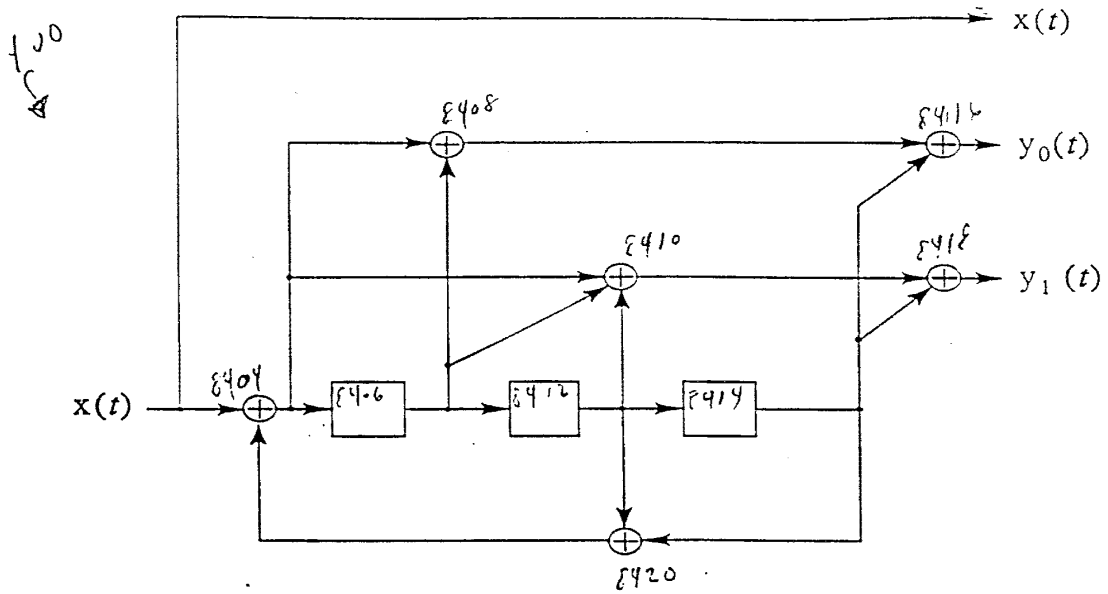
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Appendix Fig. A-84 Mother Constituent Code for Universal Turbo Codes of Rates 1/2, 1/3, 1/4, and 1/5

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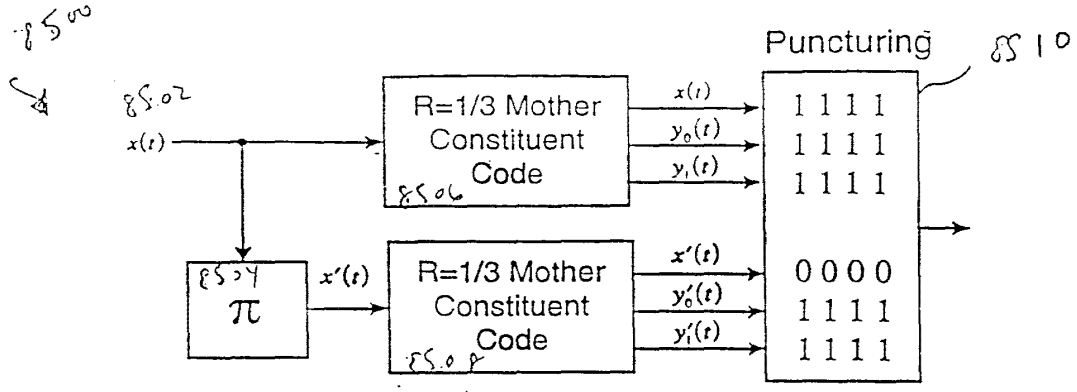
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Appendix Fig. A-85 Rate-compatible Turbo Code of Rate 1/5

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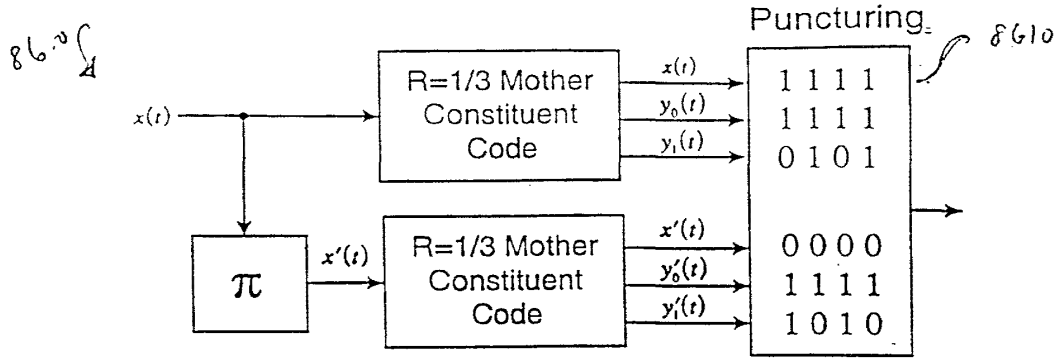
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Appendix Fig. A-86 Rate-compatible Turbo Code of Rate 1/4

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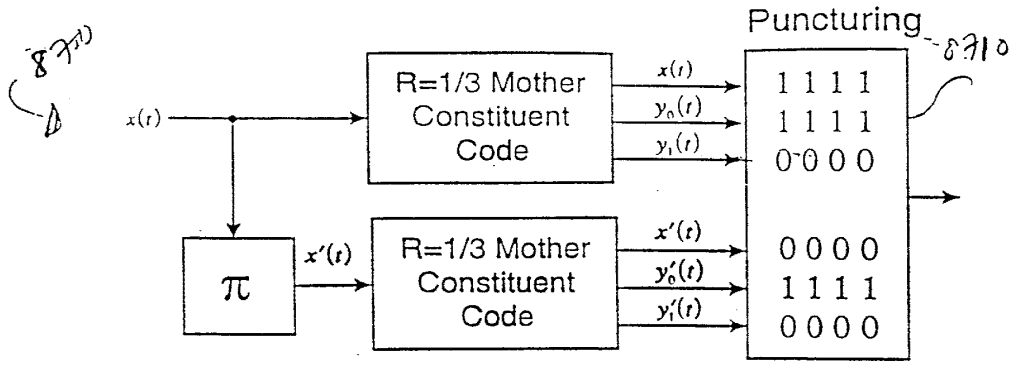
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Appendix Fig. A-87 **Rate-compatible Turbo Code of Rate 1/3**

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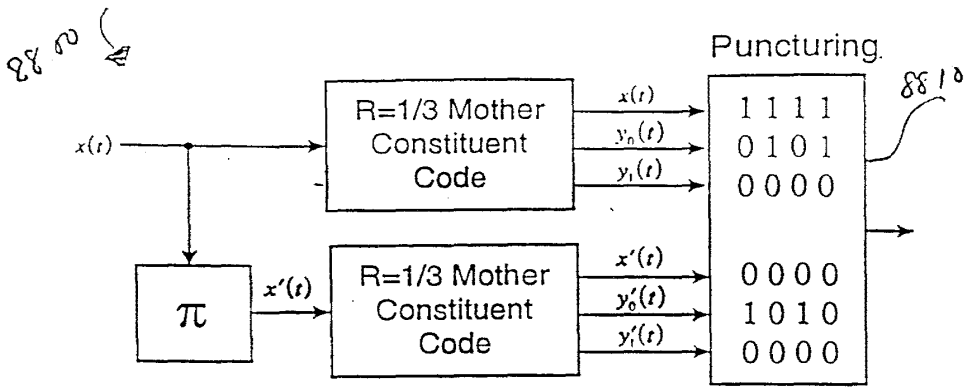
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Appendix Fig. A-88 Rate-compatible Turbo Code of Rate 1/2

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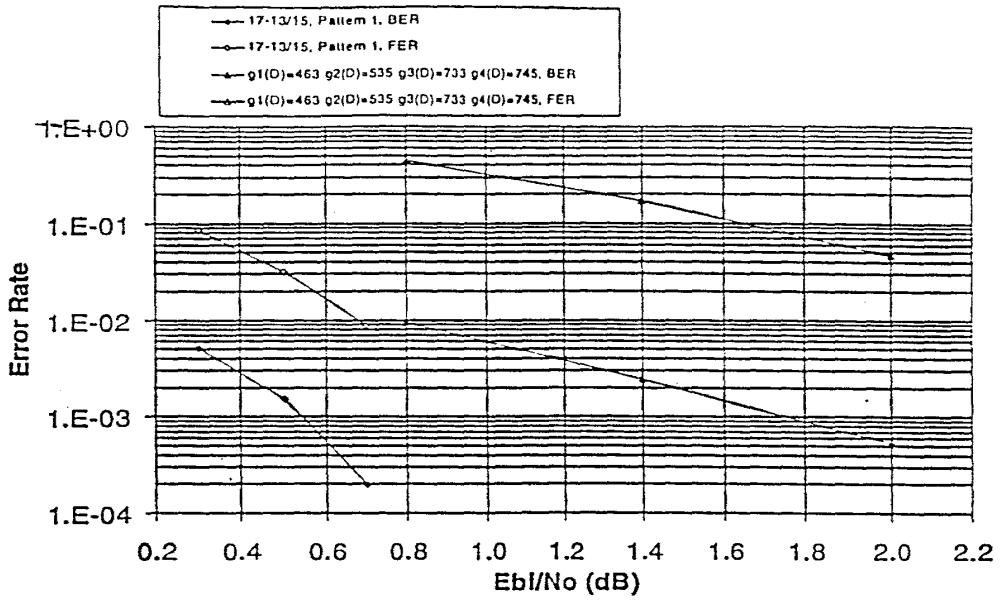
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ppendix Fig. A-89 Comparison of Rate-1/4 BER-Optimized Turbo Code vs Convolutional Code, Frame Size=512

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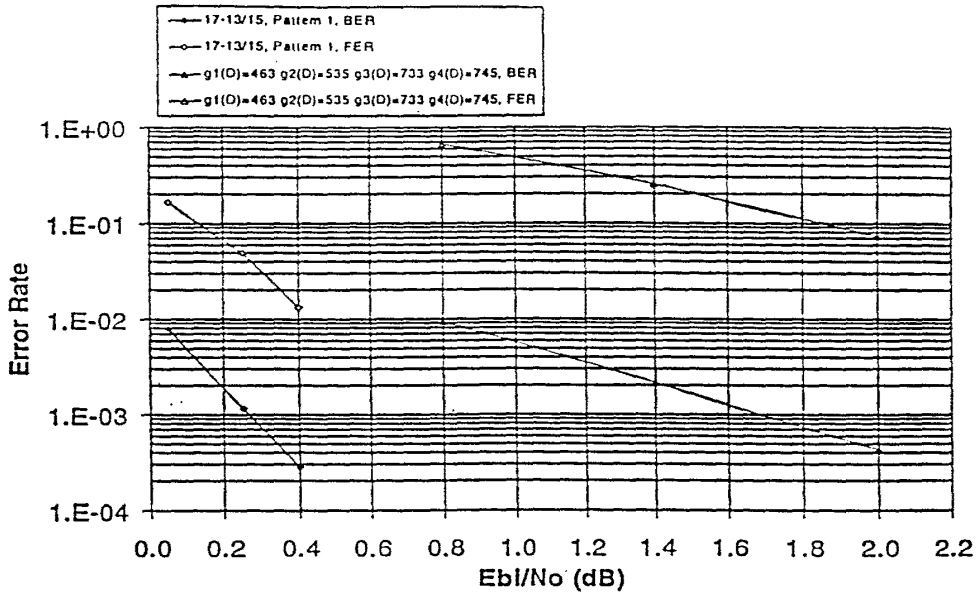
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236 A-1 CS AUG 90 *(EACH PAGE UPON WHICH INFORMATION IS ENTERED SHOULD BE SIGNED AND WITNESSED)*

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Appendix Fig. A-90 Comparison of Rate-1/4 BER-Optimized Turbo Code vs Convolutional Code, Frame Size=1024

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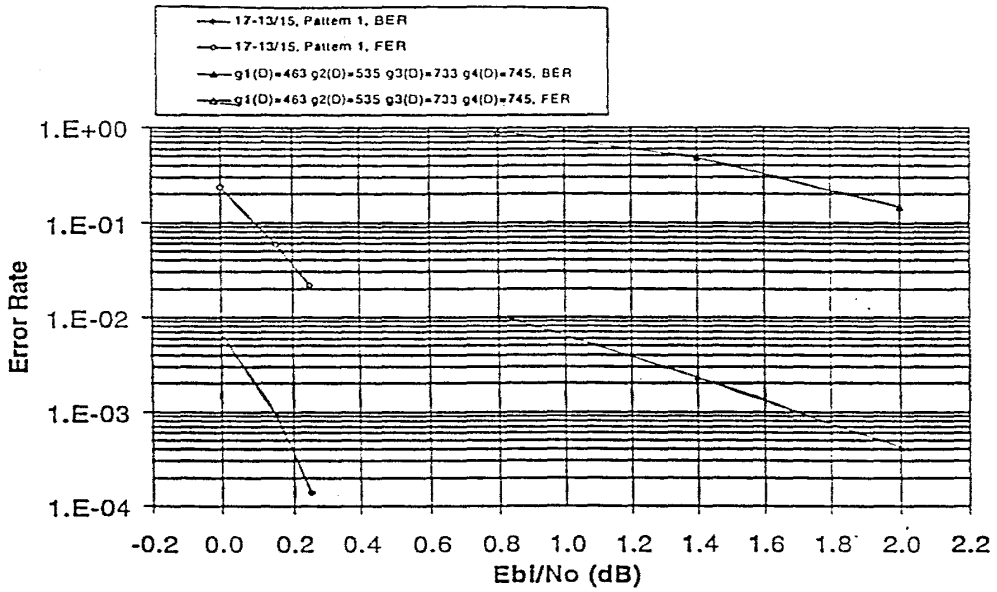
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ppendix Fig. A-91 Comparison of Rate-1/4 BER-Optimized Turbo Code vs Convolutional Code, Frame Size=2048

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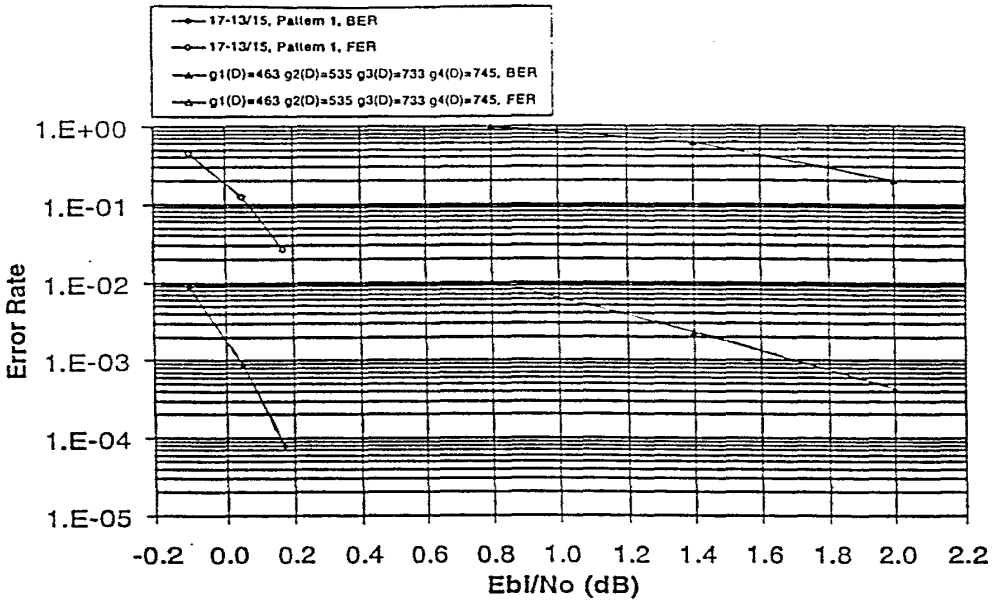
READ AND UNDERSTOOD BY:

WITNESS NAME (TYPE) SIGNATURE DATE

WITNESS NAME (TYPE) SIGNATURE DATE

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Appendix Fig. A-92 Comparison of Rate-1/4 BER-Optimized Turbo Code vs Convolutional Code, Frame Size=3072

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READ AND UNDERSTOOD BY:

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CLAIMS

What is claimed is:

1. A method of processing data in data services with a set of rate-compatible Turbo Codes optimized at high code rates and derived from a universal constituent code, the Turbo Codes having compatible puncturing patterns, the method comprising the steps of:

encoding a signal at a first and second encoder using a best rate 1/2 constituent code universal with higher and lower code rates, the first encoder and the second encoder each producing a respective plurality of parity bits for a data bit;

puncturing the respective plurality of parity bits at each encoder with a higher rate best puncturing pattern; and

puncturing the respective plurality of parity bits at each encoder with a lower rate best puncturing pattern.

2. The method of Claim 1 wherein the best rate 1/2 constituent code represents a concatenation of polynomial $1+D^2+D^3$ (octal 13) and polynomial $1+D+D^3$ (octal 15), D a data bit.

3. The method of Claim 2 wherein one of the rate-compatible Turbo Codes in the set comprises a rate 1/2 Turbo Code and further wherein one of the puncturings comprises alternately puncturing parity bits between the first and the second encoder.

4. The method of Claim 2 wherein one of the rate-compatible Turbo Codes in the set comprises a rate 1/3 Turbo Code and further wherein one of the puncturings comprises transmitting all the parity bits at the first and second encoder.

5. A method of processing data in data services using a set of rate-compatible Turbo Codes derived from an optimal universal rate 1/3 constituent code, the Turbo Codes having similar constituent codes and compatible puncturing patterns, the method comprising:

encoding a signal with a best rate 1/3 constituent code at a first and a second encoder, each encoder producing a respective plurality of parity bits for each data bit;

puncturing the plurality of parity bits with the a higher rate best puncturing pattern; and

puncturing the plurality of parity bits with a lower rate best puncturing pattern.

6. The method of Claim 5 wherein the best rate 1/3 constituent code represents a concatenation of polynomial $1+D^2+D^3$, (octal 13), polynomial $1+D+D^3$ (Octal 15), and polynomial $1+D+D^2+D^3$ (octal 17), D a data bit.

7. The method of Claim 5 wherein the set of Turbo Codes comprises a rate 1/5 Turbo Code wherein at least one of the steps of puncturings comprises transmitting all the parity bits at the first and the second encoders.

8. The method of Claim 5 wherein the set of Turbo Codes comprises a rate 1/4 Turbo Code wherein at least one of the puncturings comprises:

alternately puncturing a select group of the plurality of parity bits between the first and the second encoder.

9. The method of Claim 5 wherein the set of Turbo Codes comprises a rate 1/3 Turbo Code wherein at least one of the puncturings comprises:

puncturing a select group of the plurality of parity bits at the first and the second encoder.

10. The method of Claim 5 wherein the set of Turbo Codes comprises a rate 1/2 Turbo Code and further wherein at least one of the puncturings comprises:

puncturing at the encoders a select group of the plurality of parity bits and alternately puncturing at the encoders another select group of the plurality of parity bits.

11. A method of rate-compatible Turbo encoding using a set of rate-compatible Turbo Codes, the set optimized for code rate 1/4, and comprising Turbo Codes with differing code rates and rate-compatible puncturing patterns, the method comprising the steps of:

encoding a signal at a first and second encoder using a best rate 1/4 constituent code universal with higher and lower code rates, the first encoder and the second encoder each producing a respective plurality of parity bits for a data bit;

puncturing the respective plurality of parity bits at each encoder with a higher rate best puncturing pattern; and

puncturing the respective plurality of parity bits at each encoder with a lower rate best puncturing pattern.

12. The method of Claim 11 wherein the set of rate-compatible Turbo Codes represent a concatenation of polynomials $1+D+D^3$, $1+D^2+D^3$, and $1+D+D^3$, D a data bit, and wherein an associated rate-compatible puncturing pattern is selected from a group of patterns including:

transmitting all data;

alternately puncturing parity bits associated with polynomial $1+D+D^3$; and

puncturing parity bits associated with polynomial $1+D+D^3$ for each encoder.

13. The method of Claim 11 wherein the set of rate-compatible Turbo Codes comprise two or more Turbo Codes of differing rates selected from a group of rates including 1/5 and 1/4, the Turbo Codes representing a concatenation of polynomials $1+D+D^3$, $1+D^2+D^3$, and $1+D+D^2+D^3$, D a data bit, and wherein an associated rate-compatible puncturing pattern is selected from the group of patterns including:

transmitting all data; and

alternately puncturing parity bits associated with polynomial $1+D+D^2+D^3$.

14. An encoding system using a set of rate-compatible Turbo Codes derived from a best universal rate 1/2 constituent

code, the set having compatible puncturing patterns, the system comprising:

a first and second encoder, each encoder comprising:

a plurality of shift registers;

a plurality of adders each adder coupled to a selected portion of the adders in a configuration corresponding to the best universal rate 1/2 constituent code; and

a puncturer configured with the first and second encoder to puncture a plurality of data outputs from each of the first and second encoder, the puncturing determined by a desired Turbo Code rate in accordance with the set of the compatible puncturing patterns.

15. An encoding system using a set of rate-compatible Turbo Codes derived from an optimal universal rate 1/3 constituent code, the rate compatible Turbo Codes having similar constituent codes and compatible puncturing patterns, the system comprising:

a first and second encoder, each encoder comprising:

a plurality of shift registers;

a plurality of adders, each of the adders coupled to a selected portion of the adders in a configuration corresponding to the rate 1/3 constituent code of; and

a puncturer configured with the first and second encoder such to puncture a plurality of data outputs from the first and second encoder, the puncturing determined by a desired Turbo Code rate in accordance with the set of the compatible puncturing patterns.

16. An encoding system using a set of rate-compatible Turbo Codes comprising Turbo Codes having a universal constituent code and rate-compatible puncturing patterns for different code rates, the system comprising:

a first and second encoder, each encoder comprising:

a plurality of shift registers;

a plurality of adders each adder coupled to a selected portion of the plurality of adders in a configuration corresponding to the universal constituent code; and

a puncturer configured with the first and second encoder for puncturing a plurality of data outputs from the first and second encoder, the puncturing determined by a desired Turbo Code rate in accordance with the set of compatible puncturing patterns.

17. A method of determining a set of rate-compatible Turbo Codes, optimized at high code rates , the set derived from a best universal constituent code of rate 1/2 compatible with higher codes, the Turbo Codes having compatible puncturing patterns, the method comprising the steps of:

selecting a group of candidate mother constituent code pairs comprising primitive, irreducible polynomials based upon code pair screening and diversity,
the code pair screening comprising simulating relative Bit Error Rate (BER) performance of rate 1/2 and 1/3 Turbo Codes at a fixed Interleaver length;

measuring an relative Signal-to-Noise ratio loss of a signal after a plurality of encodings for each candidate pair at both a plurality of different Interleaver depths and two different Turbo Code rates, wherein each encoding has a

different combination of candidate pair, Interleaver depth, and rate;

selecting a best candidate pair based upon a best relative Signal-to-Noise loss from the measuring; and

selecting at least one lower rate and one higher rate best puncturing pattern for the best candidate pair, for each of the two or more rate-compatible Turbo Codes of the set, wherein the at least one higher rate pattern selects transmittal of any parity bits selected for transmittal by the at least one lower rate pattern of the set.

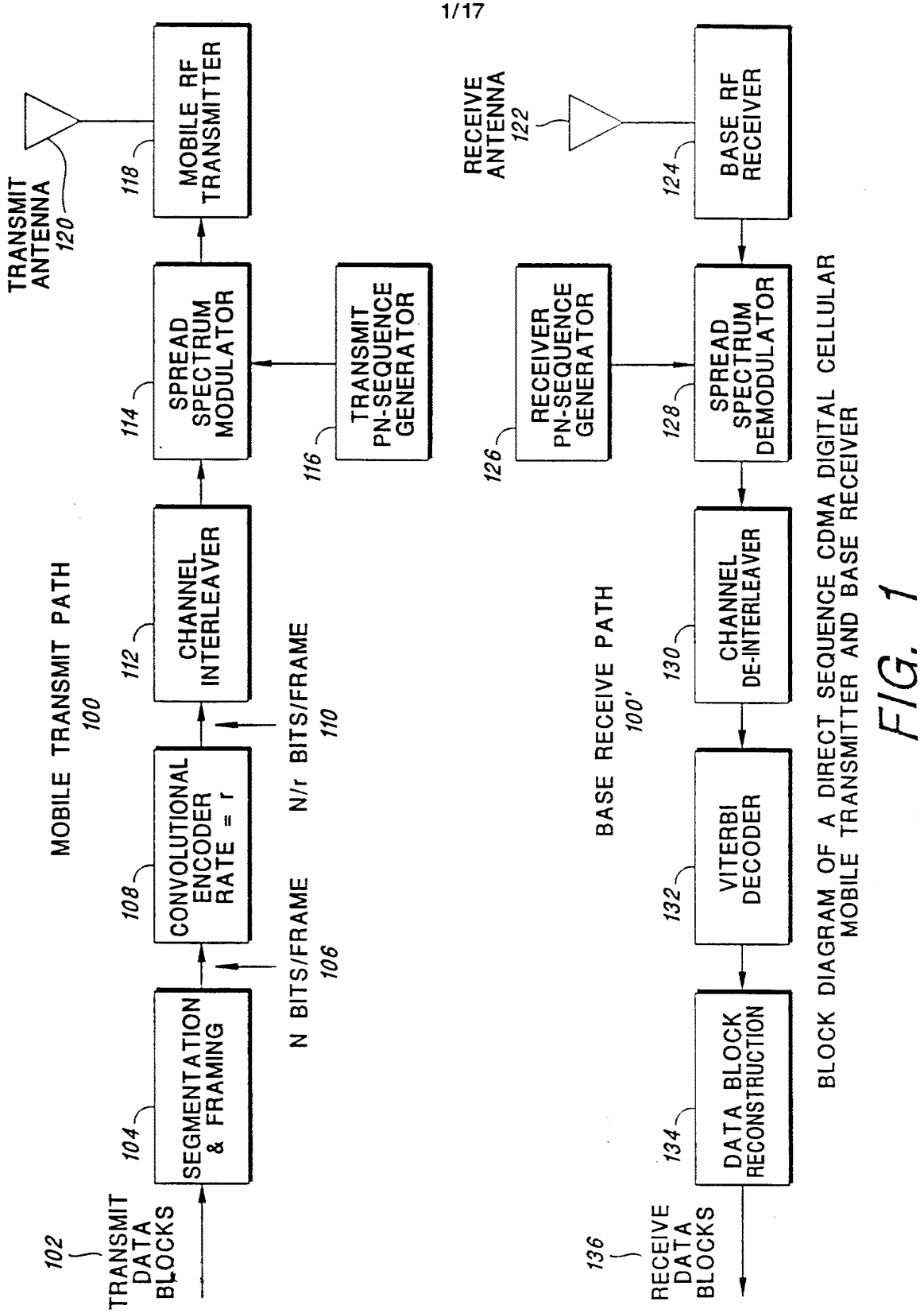


FIG. 1

BLOCK DIAGRAM OF A DIRECT SEQUENCE CDMA DIGITAL CELLULAR MOBILE TRANSMITTER AND BASE RECEIVER

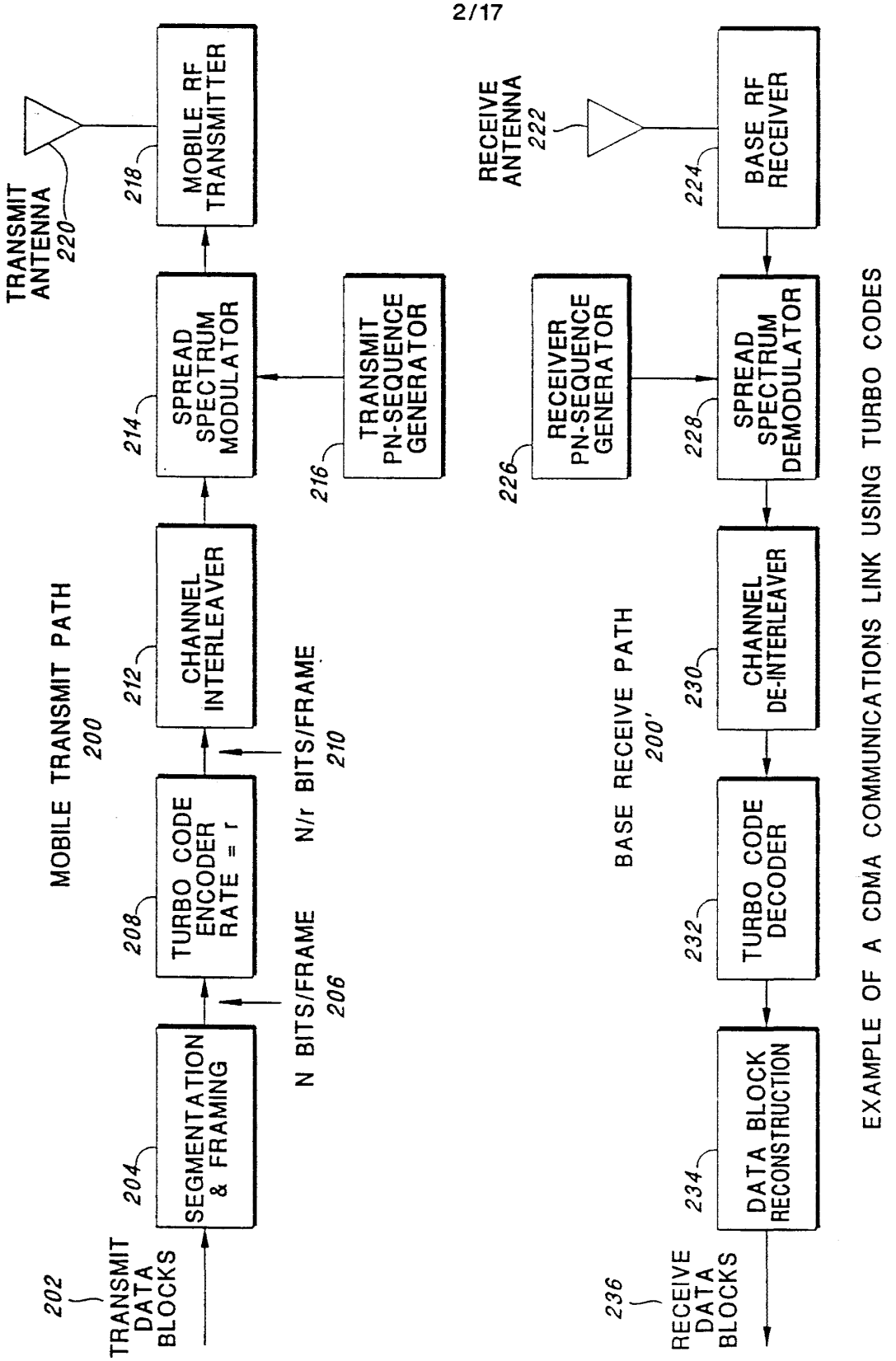


FIG. 2

EXAMPLE OF A CDMA COMMUNICATIONS LINK USING TURBO CODES

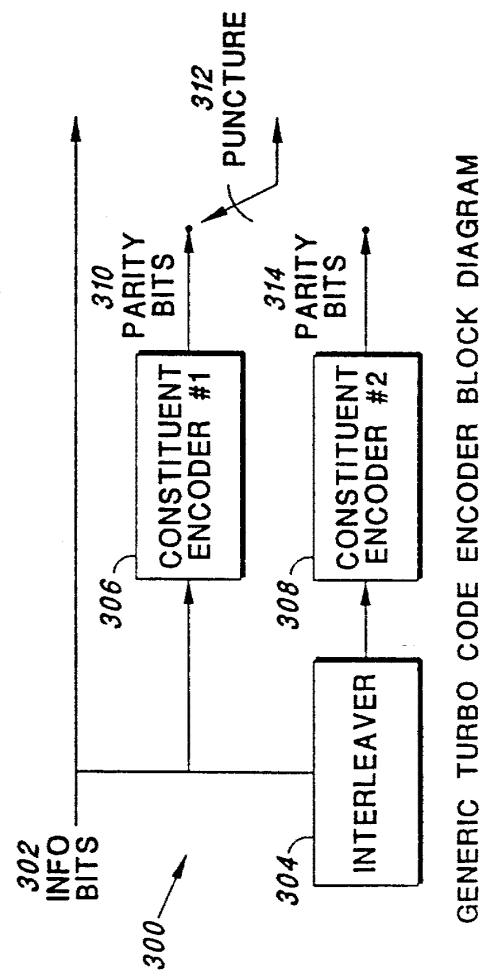

300
302 INFO BITS
304 INTERLEAVER
306 CONSTITUENT ENCODER #1
308 CONSTITUENT ENCODER #2
310 PARITY BITS
312 PUNCTURE
314 PARITY BITS
GENERIC TURBO CODE ENCODER BLOCK DIAGRAM

FIG. 3

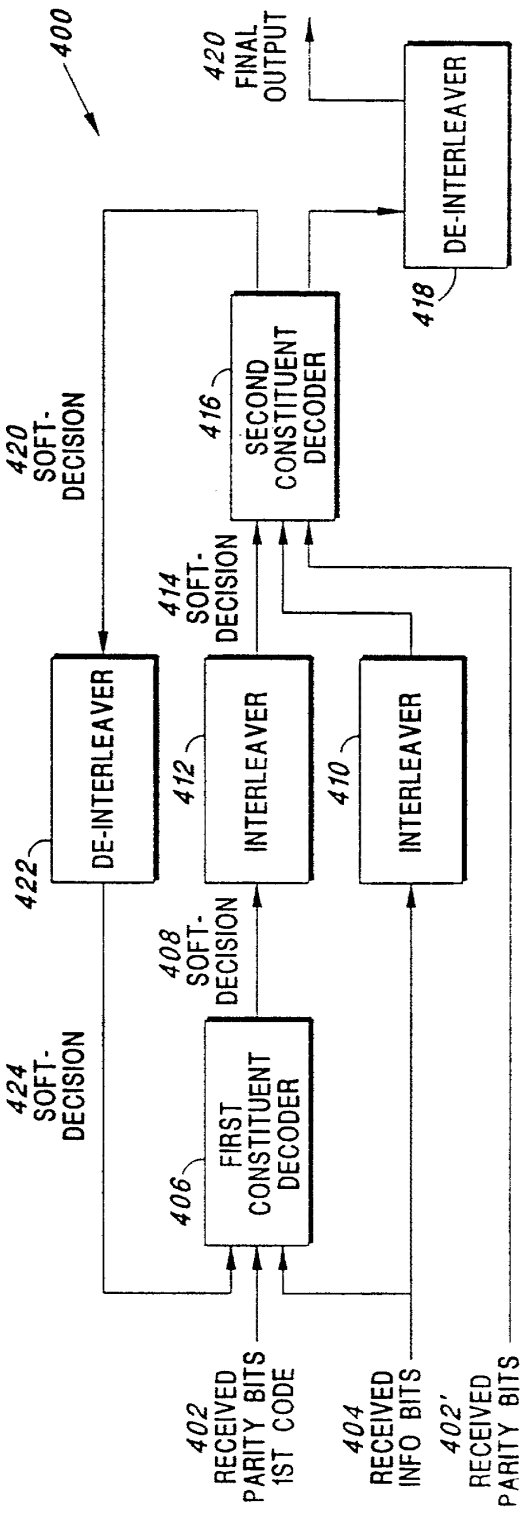

400
402 RECEIVED PARITY BITS 1ST CODE
402' RECEIVED PARITY BITS 2ND CODE
404 RECEIVED INFO BITS
406 FIRST CONSTITUENT DECODER
408 SOFT-DECISION
410 INTERLEAVER
412 INTERLEAVER
414 SOFT-DECISION
416 SECOND CONSTITUENT DECODER
418 DE-INTERLEAVER
420 FINAL OUTPUT
420 SOFT-DECISION
422 DE-INTERLEAVER
424 SOFT-DECISION

FIG. 4

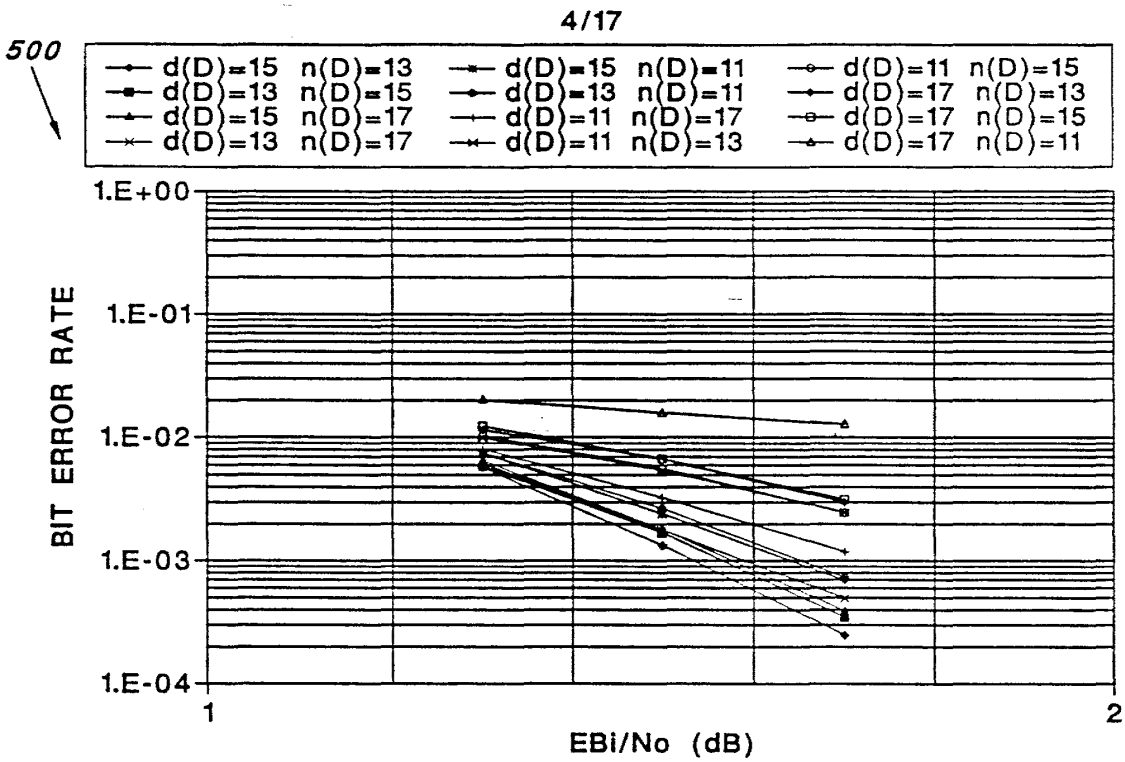


FIG. 5 RATE-1/2 TURBO CODES ON AWGN CHANNEL. (1000 BIT INTERLEAVER, 3 ITERATIONS)

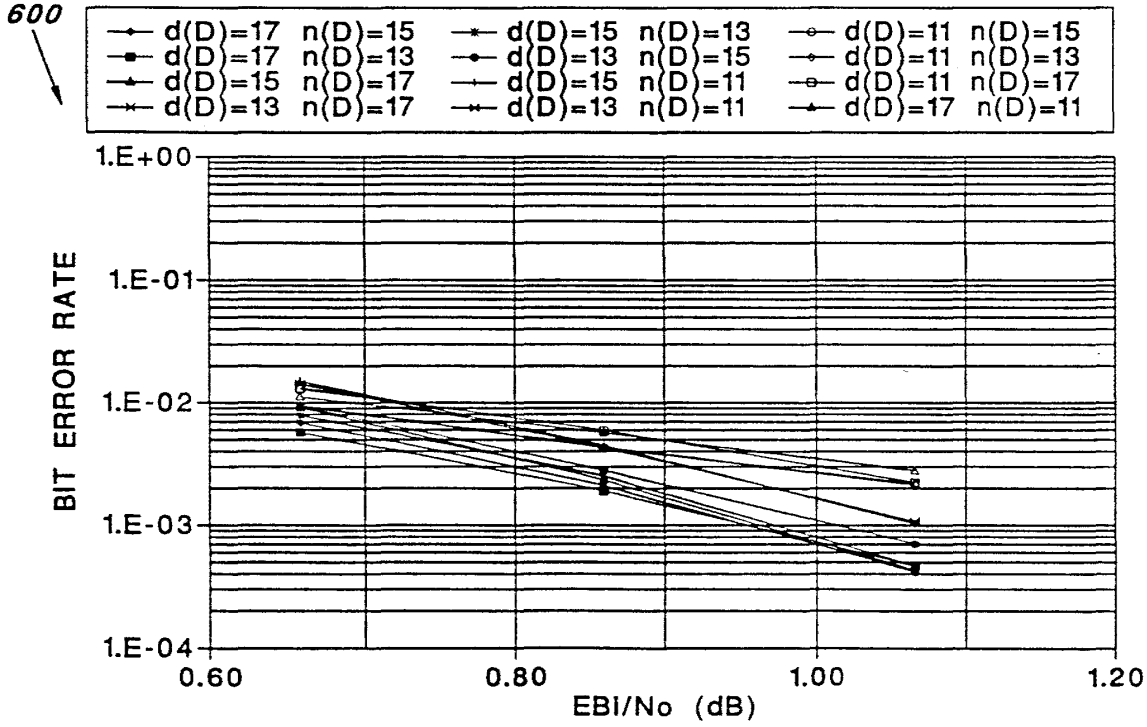


FIG. 6 RATE-1/3 TURBO CODES ON AWGN CHANNEL. (1000 BIT INTERLEAVER, 3 ITERATIONS)

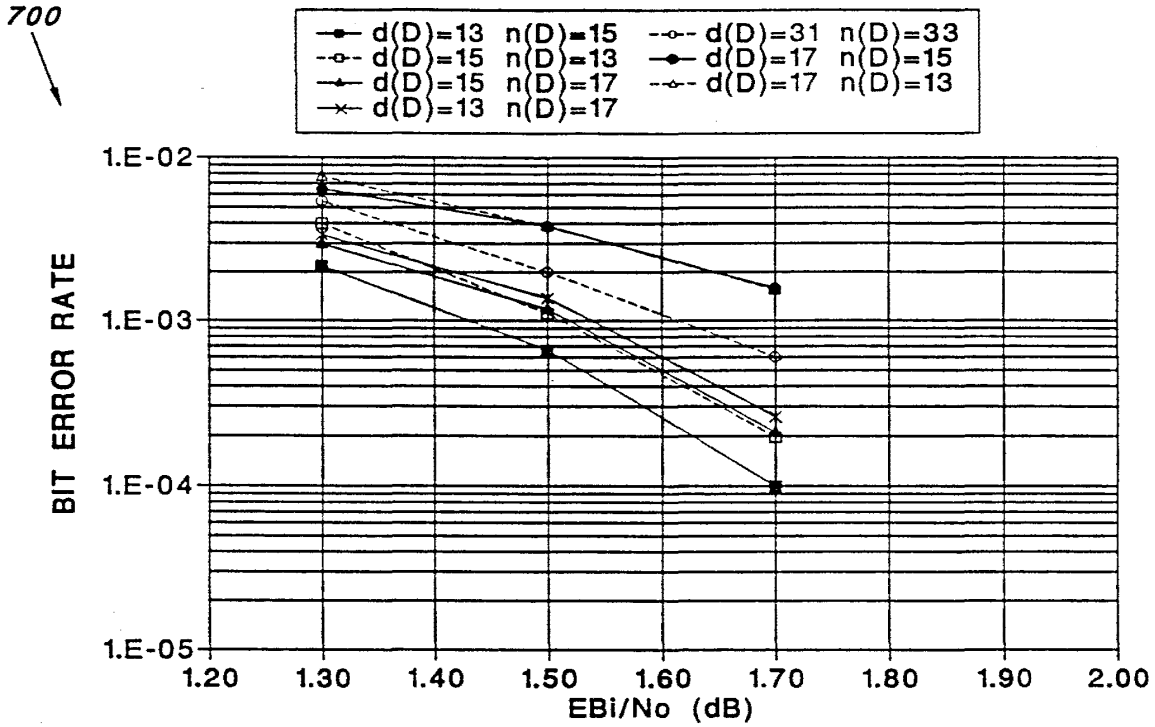


FIG. 7 SELECTED RATE 1/2 TURBO CODES ON AWGN CHANNEL, 512 BIT FRAME SIZE

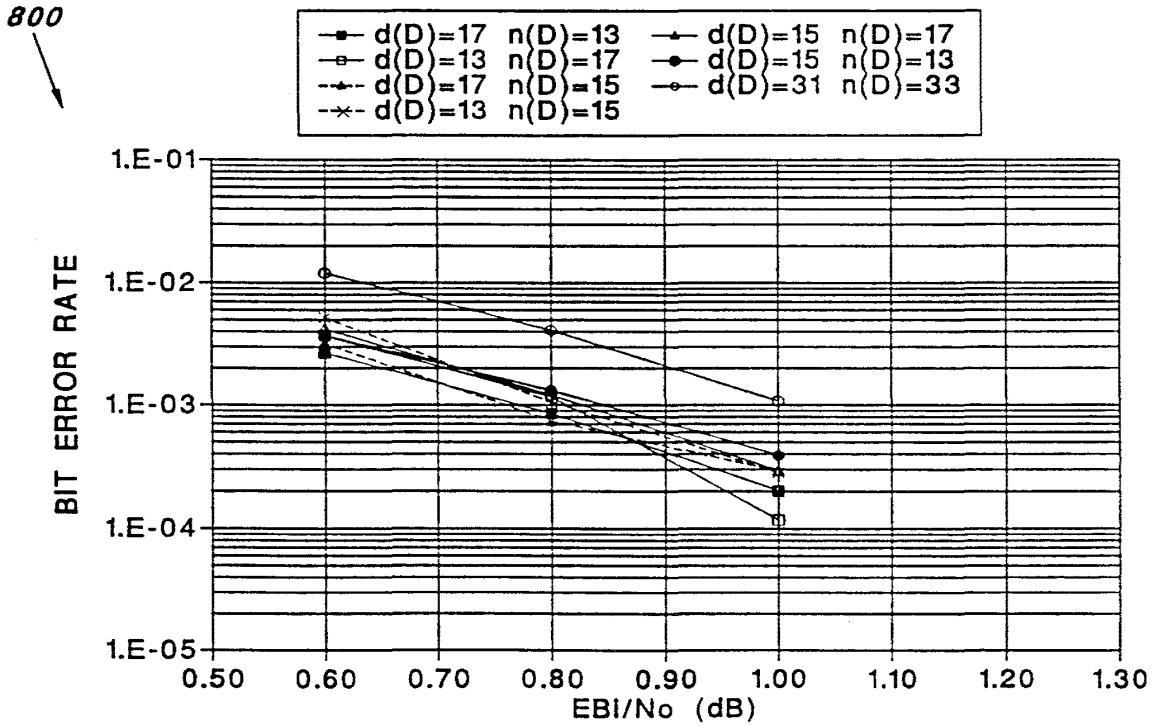


FIG. 8 SELECTED RATE 1/3 TURBO CODES ON AWGN CHANNEL, 512 BIT FRAME SIZE

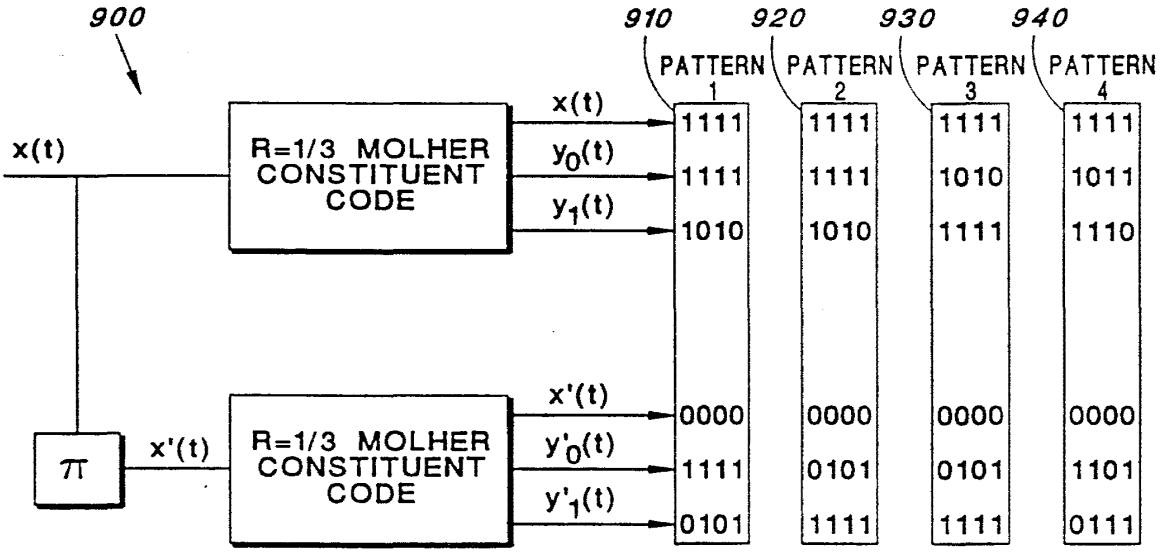


FIG. 9 PUNCTURING SCHEMES STUDIED FOR OPTIMIZING THE RATE 1/4 TURBO CODE

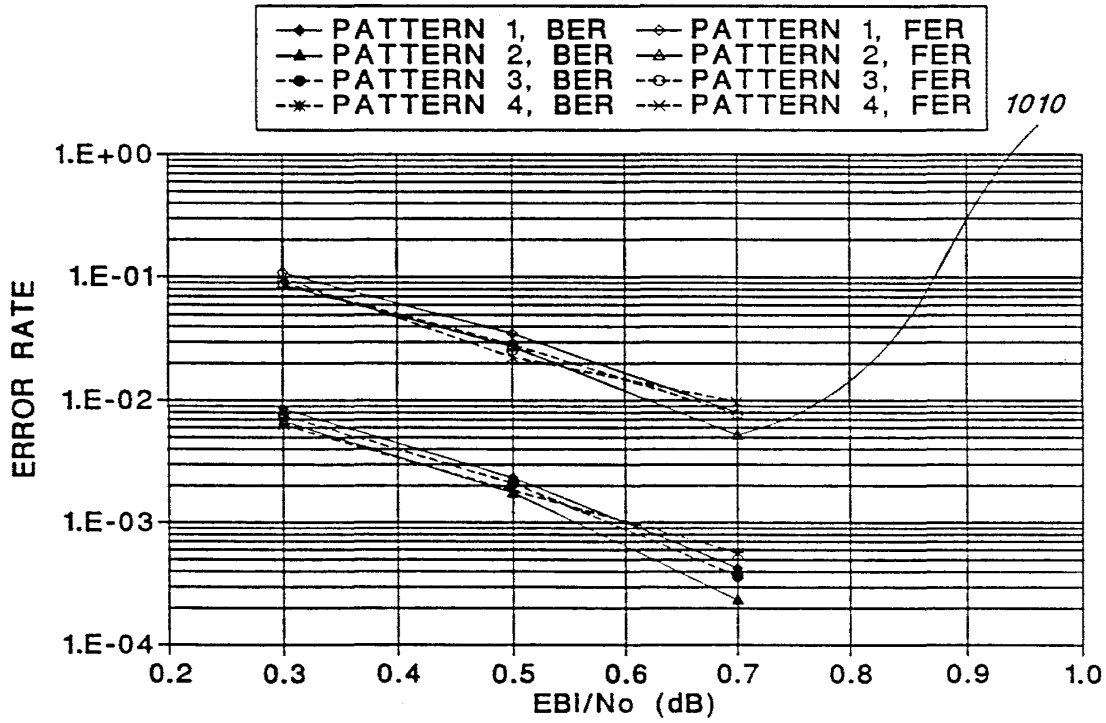


FIG. 10 PERFORMANCE OF CODE #1, FRAME SIZE=512

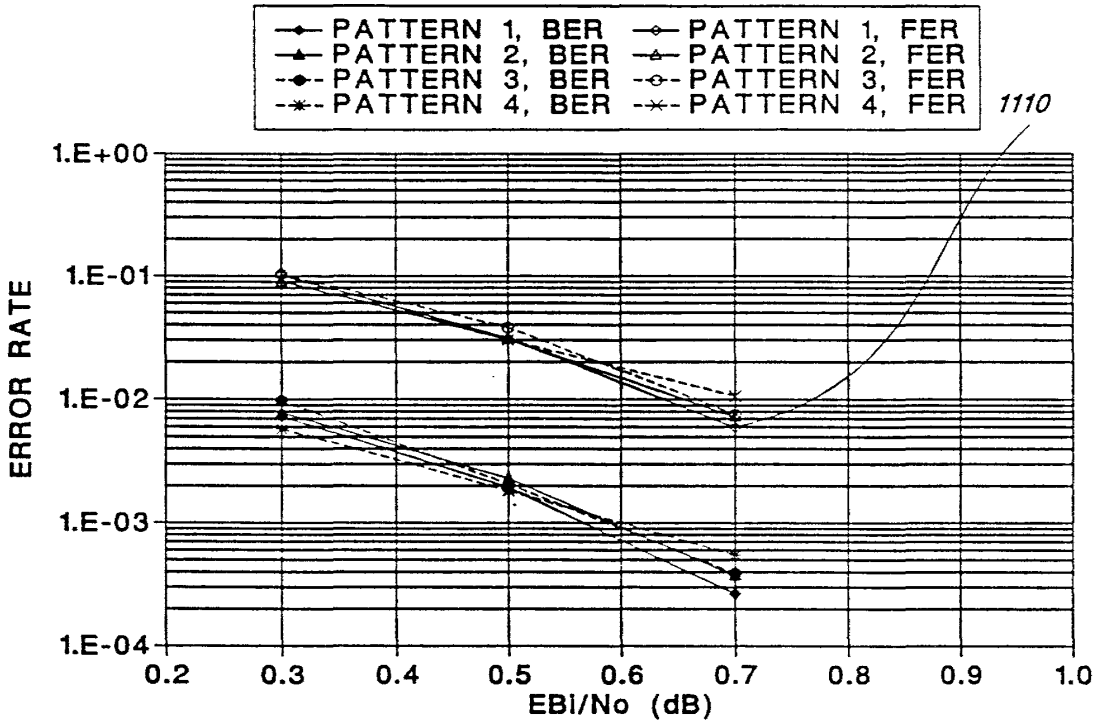


FIG. 11 PERFORMANCE OF CODE #2, FRAME SIZE=512

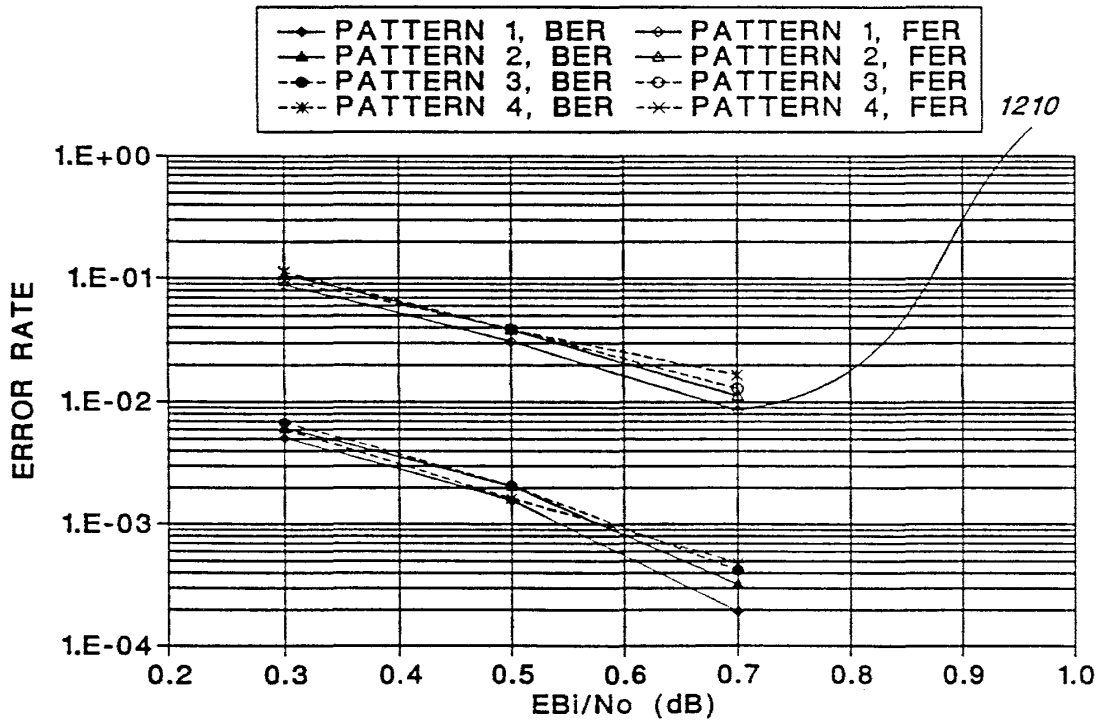


FIG. 12 PERFORMANCE OF CODE #3, FRAME SIZE=512

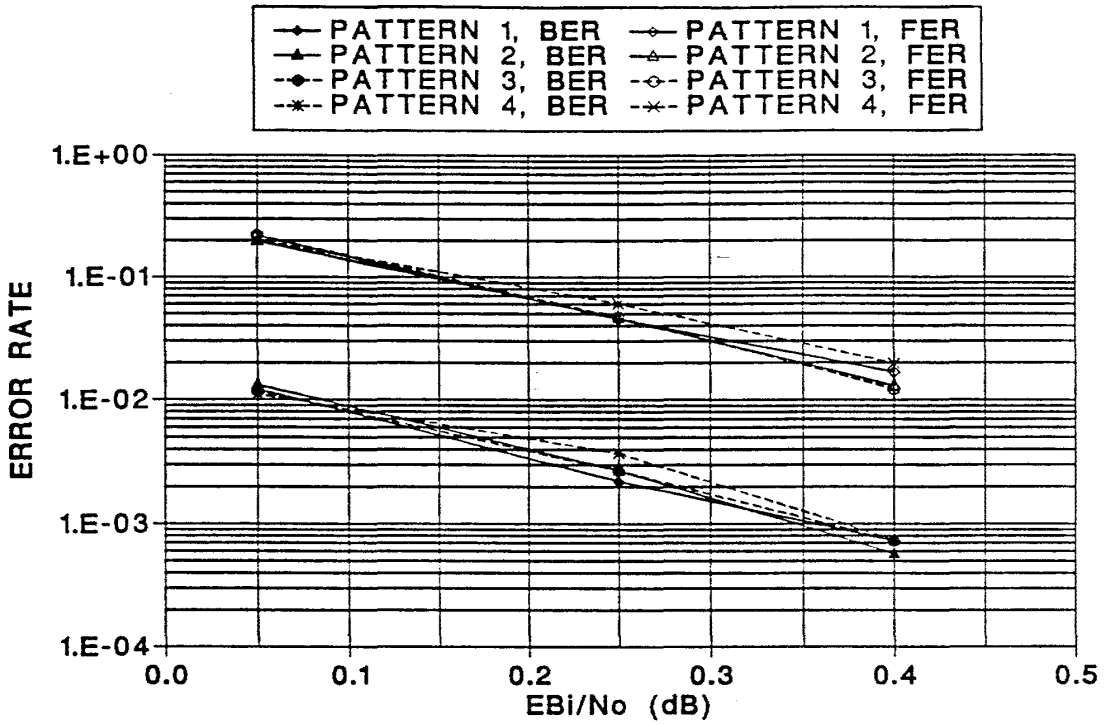


FIG. 13 BER/FER PERFORMANCE OF CODE #1, FRAME SIZE=1024

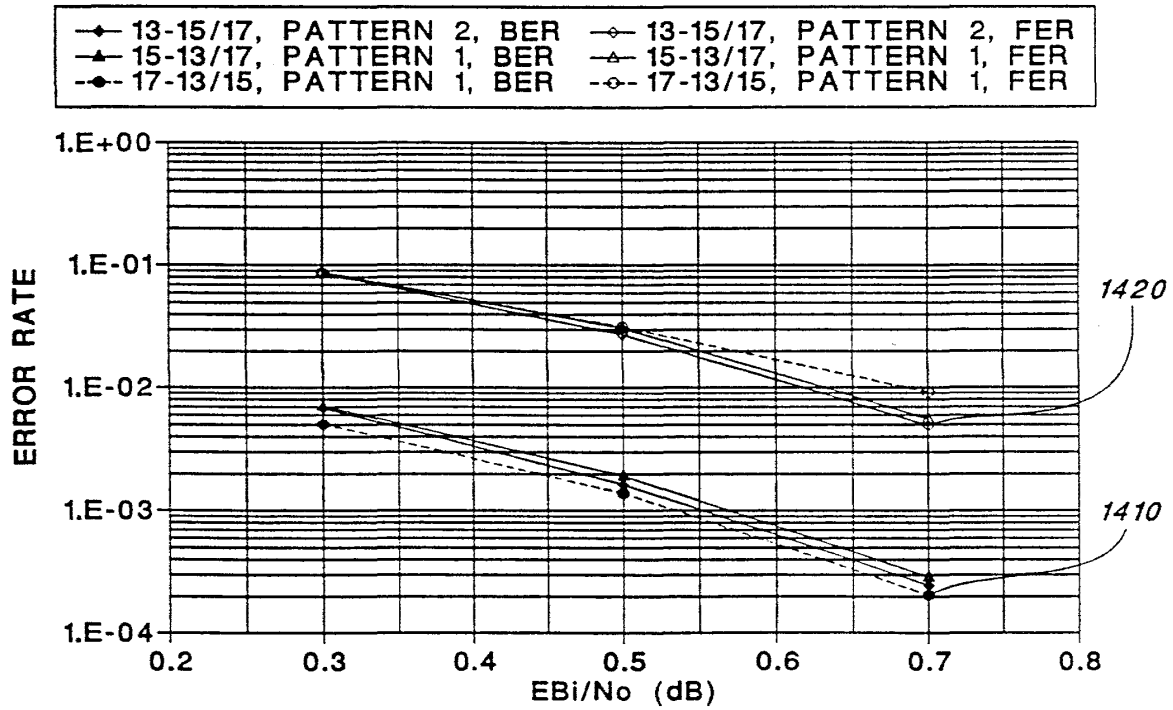


FIG. 14 BER/FER PERFORMANCE OF SELECTED RATE-1/4 TURBO CODES, FRAME SIZE=512

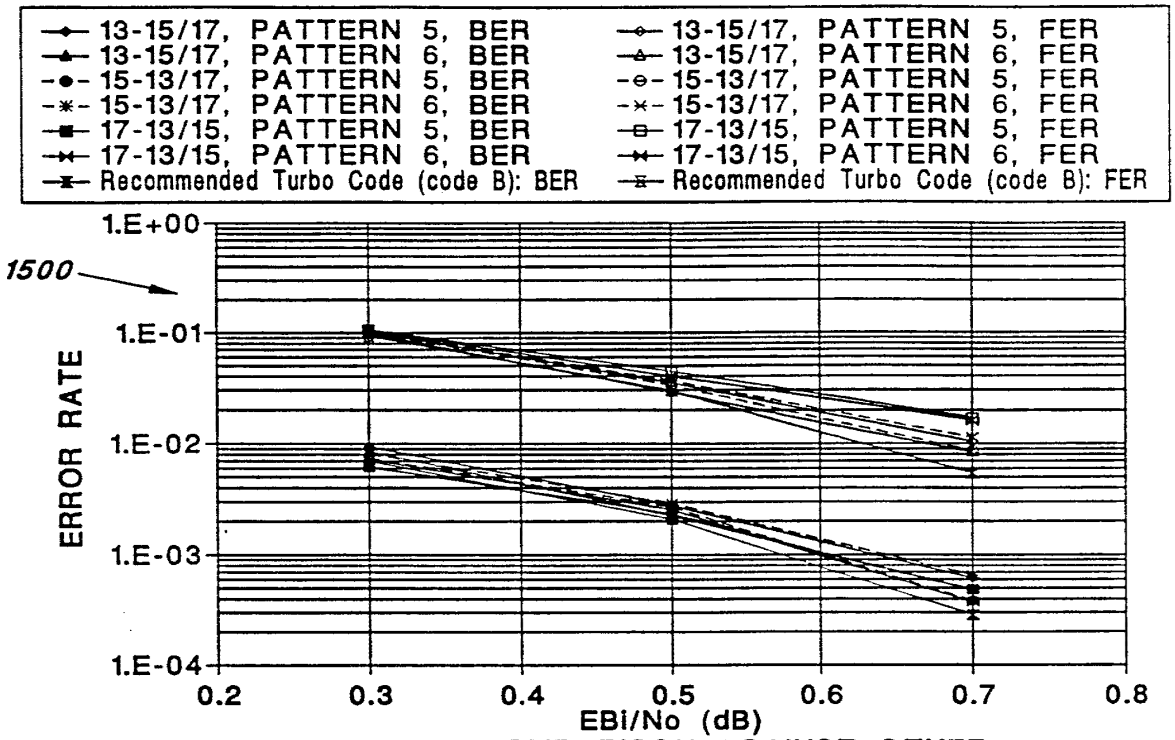


FIG. 15 COMPARISON AGAINST OTHER PUNCTURING SCHEMES, FRAME=512

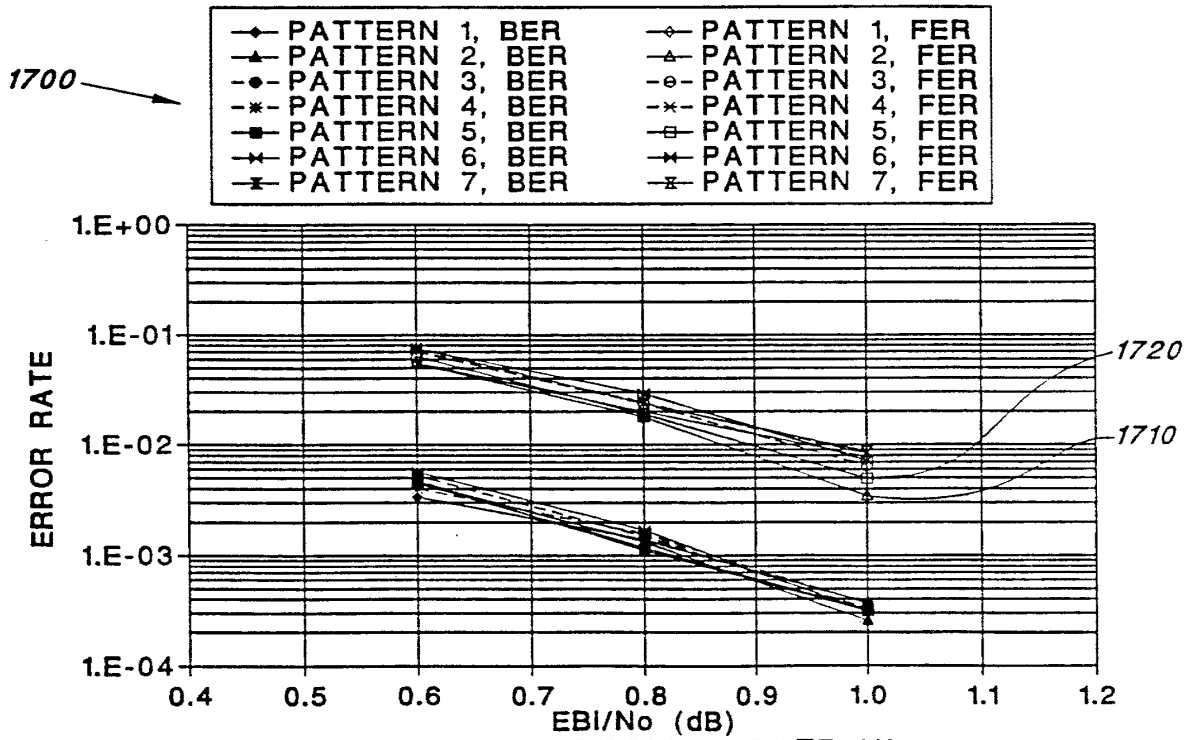


FIG. 17 COMPARISON OF RATE 1/3 PUNCTURING SCHEMES, FRAME=512

1600

1602 PATTERN 1	1604 PATTERN 2	1606 PATTERN 3	1608 PATTERN 4	1610 PATTERN 5	1612 PATTERN 6	1614 PATTERN 7	
1111	1111	1111	1111	1111	1111	1111 — 1620	1616
1111	0000	1010	1110	1111	1110	0001 — 1622	
0000	1111	0101	0001	0000	0001	1110 — 1624	
0000	0000	0000	0000	0000	0000	0000 — 1626	1618
1111	0000	1010	0001	0000	1110	0001 — 1628	
0000	1111	0101	1111	1111	0001	1110 — 1630	

(a) TURBO CODE RATE = 1/3

1640 PATTERN 1	1642 PATTERN 2	1644 PATTERN 3	1646 PATTERN 4
1111	1111	1111	1111
1010	0000	1000	1010
0000	1010	0010	0000
0000	0000	0000	0000
0101	0000	0001	0000
0000	0101	0100	0101

(b) TURBO CODE RATE = 1/2

FIG. 16 ESSENTIAL PUNCTURING PATTERNS FOR RATE 1/3 COSTITUENT CODES

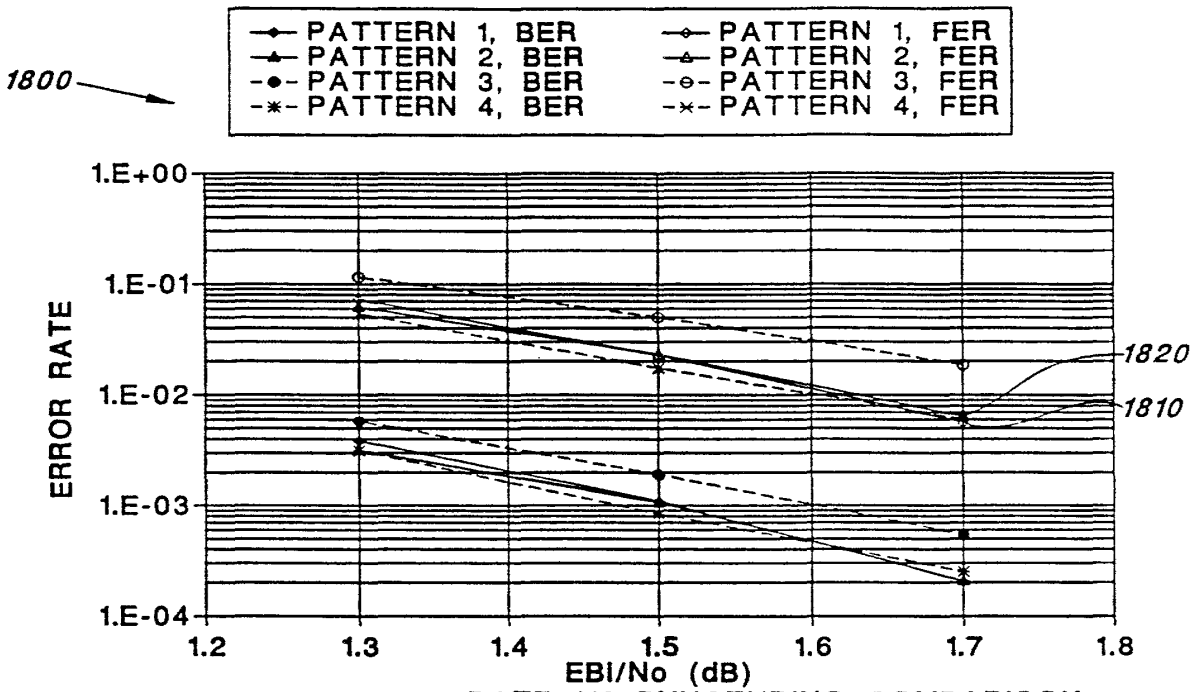


FIG. 18 RATE 1/2 PUNCTURING COMPARISON, FRAME=512

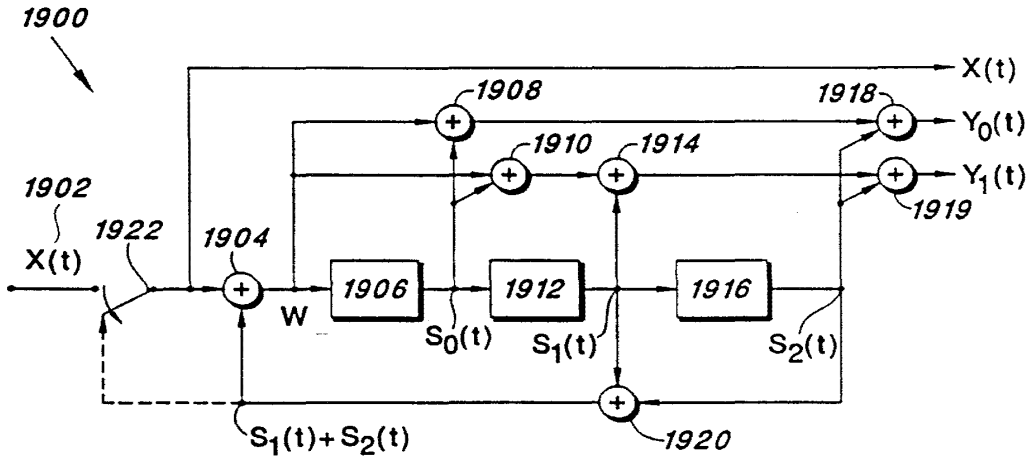


FIG. 19 UNIVERSAL CONSTITUENT ENCODER RECOMMENDED FOR FORWARD LINK TURBO CODES OF VARYING INTERLEAVER DEPTH

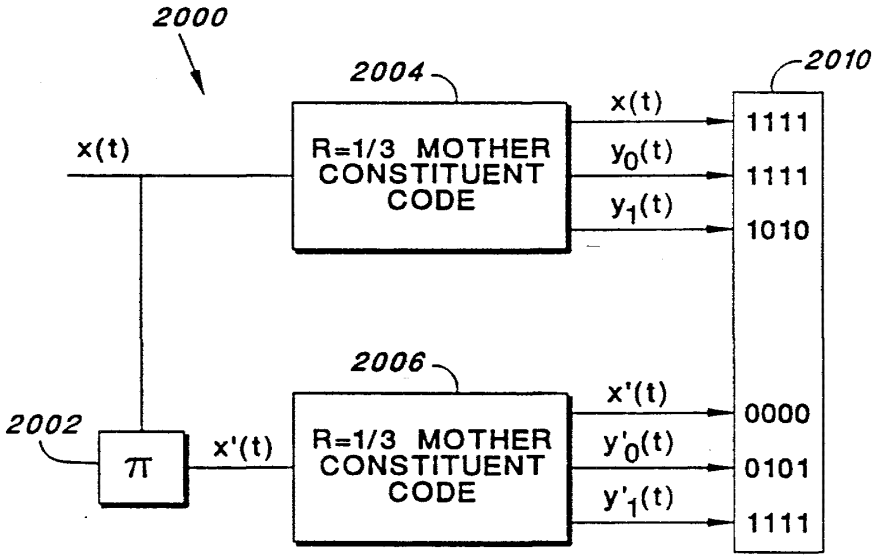


FIG. 20 FORWARD LINK TURBO CODE OF RATE 1/4 (MOTHER CODE IN FIGURE 19)

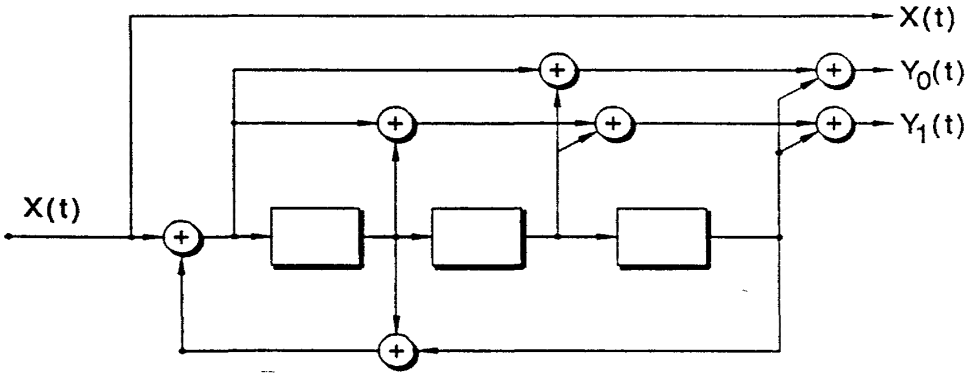


FIG. 25 CONSTITUENT ENCODER FOR REVERSE-LINK TURBO CODE

PATTERN 1	PATTERN 2
111	111111
111	111110
000	000000
000	000000
110	110111
000	000000

PUNCTURING PATTERNS FOR RATE 3/8 FORWARD LINK CODES

FIG. 21

PATTERN 1	PATTERN 2
1111	11111111
1101	11011010
0000	00000000
0000	00000000
1010	10101101
0000	00000000

PUNCTURING PATTERNS FOR RATE 4/9 FORWARD LINK CODES

FIG. 23

PATTERN 1	PATTERN 2	PATTERN 3
1111	1111	1111
1111	1011	1111
1011	1111	1011
0000	0000	0000
1111	1110	1110
1110	1111	1111

PUNCTURING PATTERNS FOR RATE 2/9 REVERSE LINK CODES

FIG. 27

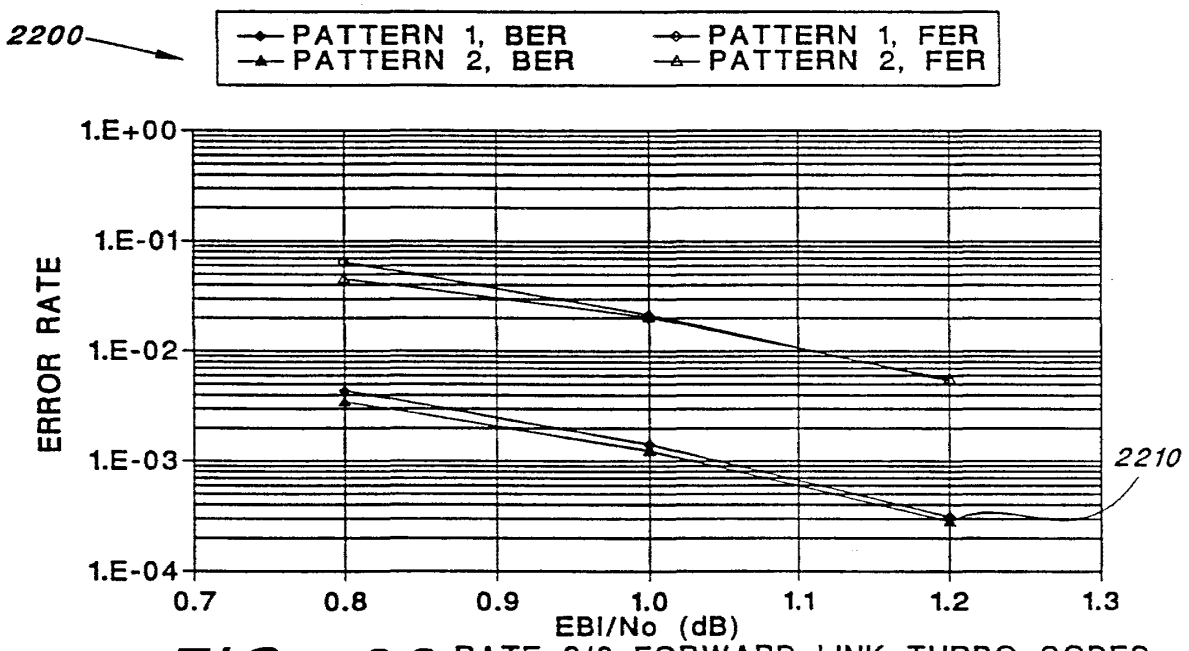


FIG. 22 RATE 3/8 FORWARD LINK TURBO CODES, FRAME=512, AWGN CHANNEL

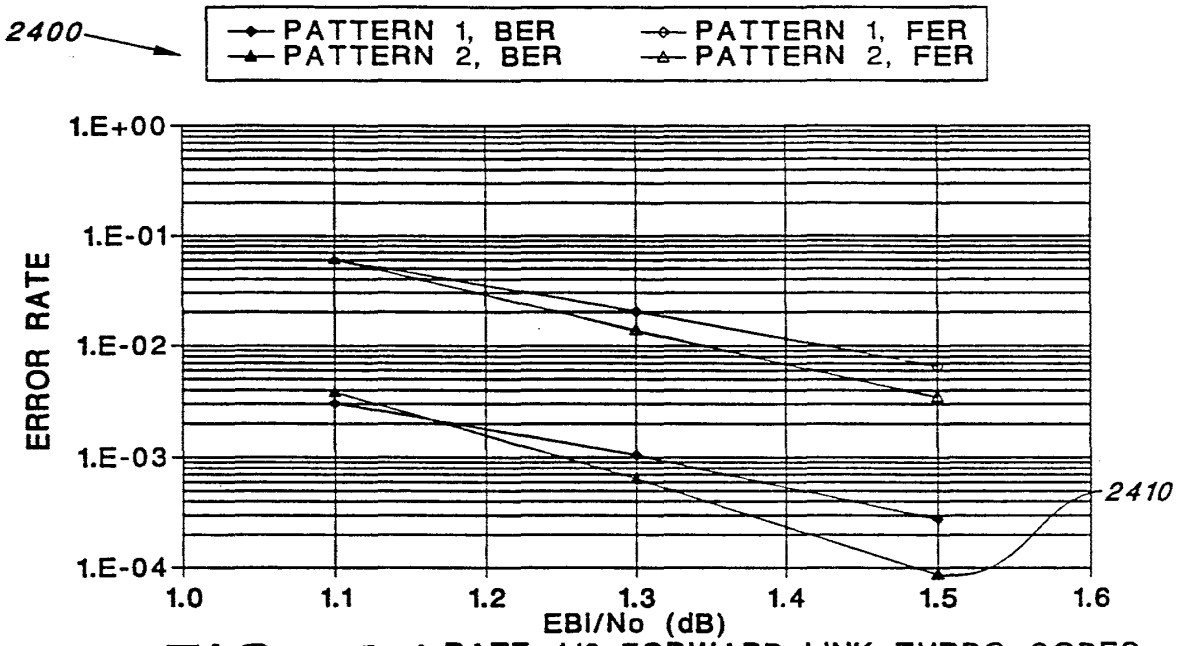


FIG. 24 RATE 4/9 FORWARD LINK TURBO CODES, FRAME=512, AWGN CHANNEL

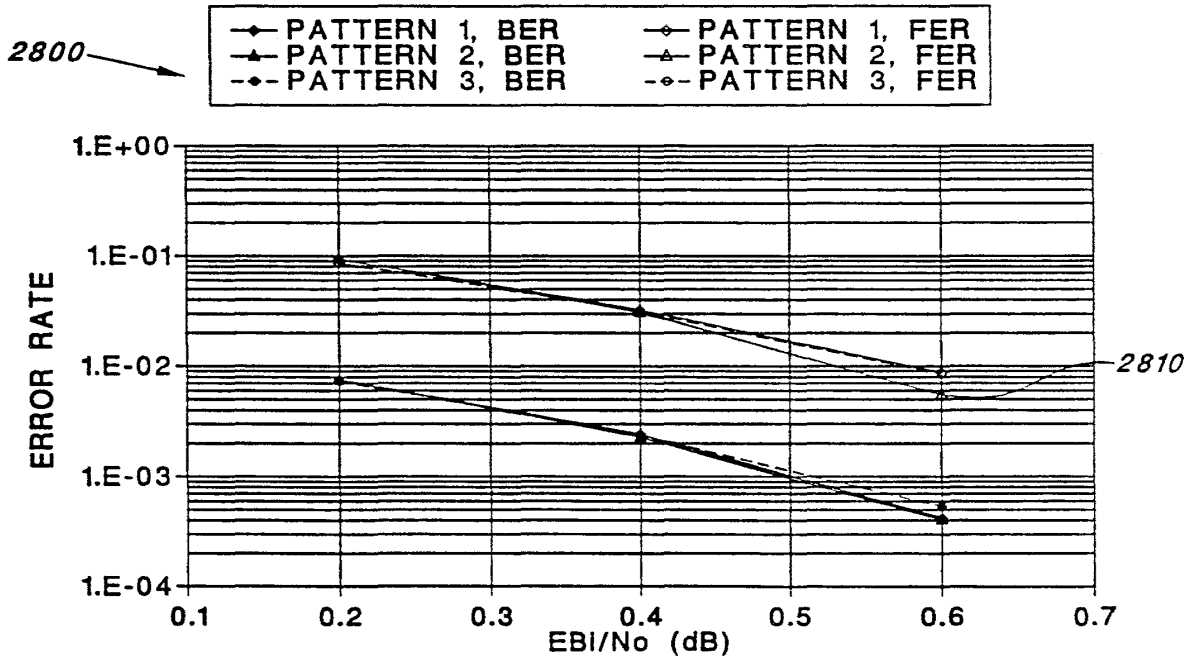


FIG. 28 RATE 2/9 REVERSE LINK TURBO CODES, FRAME=512, AWGN CHANNEL

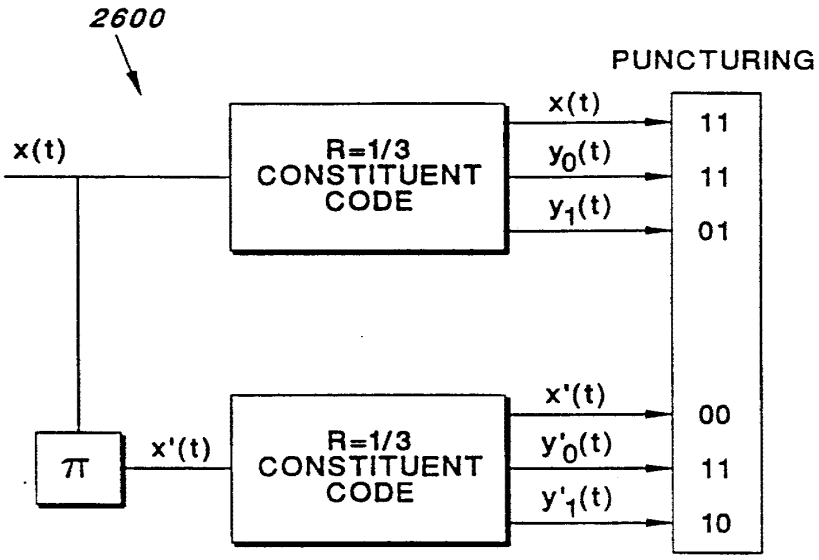


FIG. 26 REVERSE LINK TURBO CODE OF RATE 1/4 (MOTHER CODE IN FIGURE 25)

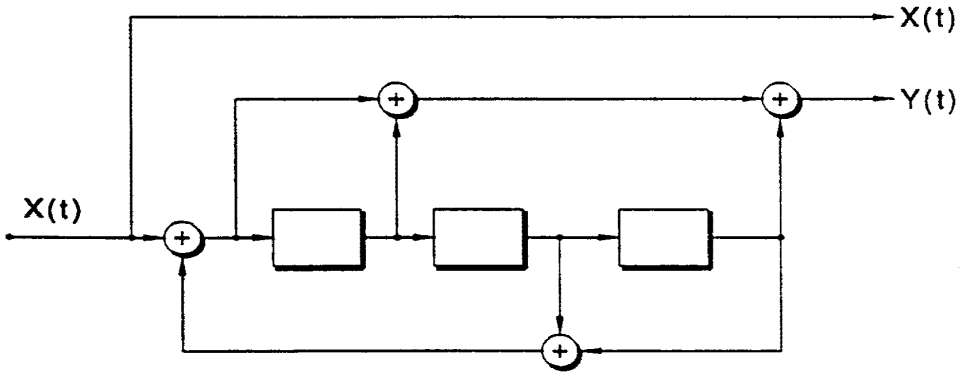


FIG. 31 UNIVERSAL CONSTITUENT ENCODER RECOMMENDED FOR R=1/2 AND R=1/3 TURBO CODES OF VARYING INTERLEAVER DEPTH

PATTERN 1	PATTERN 2	PATTERN 3
111	111	111
111	110	110
000	001	001
000	000	000
110	110	010
000	000	100

PATTERN 4	PATTERN 5	PATTERN 6
111	111	111
100	100	000
011	011	111
000	000	000
010	000	000
100	110	110

INITIAL PUNCTURING PATTERNS
FOR RATE 3/8 REVERSE LINK CODES

FIG. 29

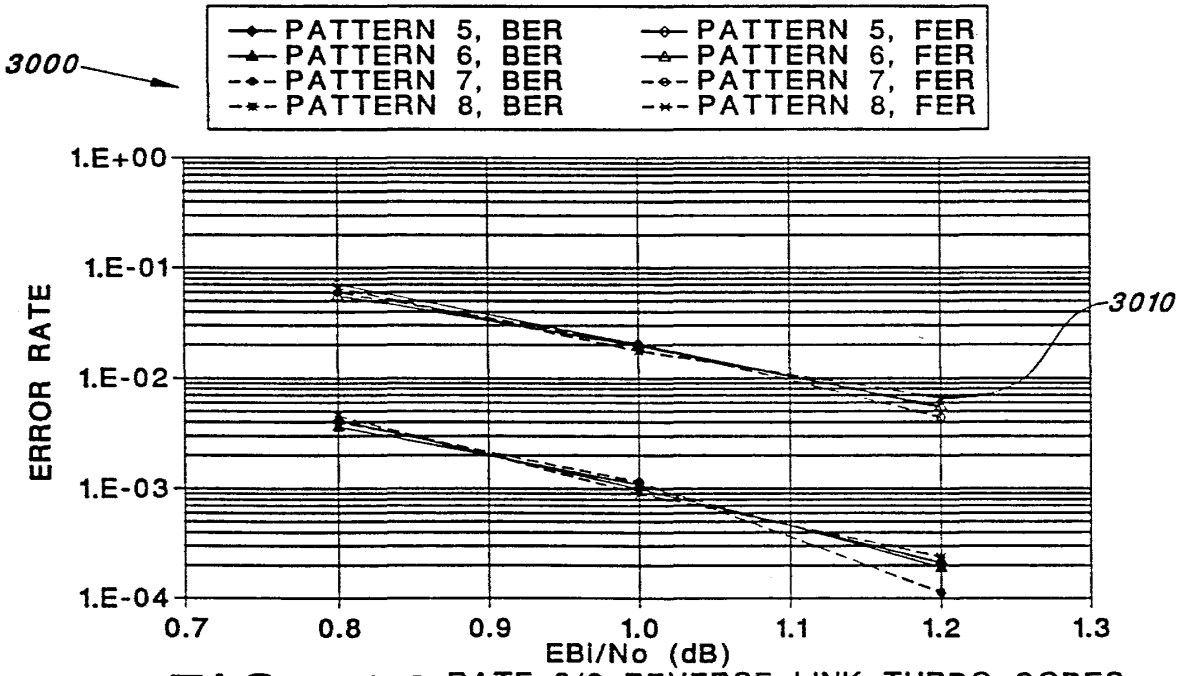


FIG. 30 RATE 3/8 REVERSE LINK TURBO CODES, FRAME=512, AWGN CHANNEL

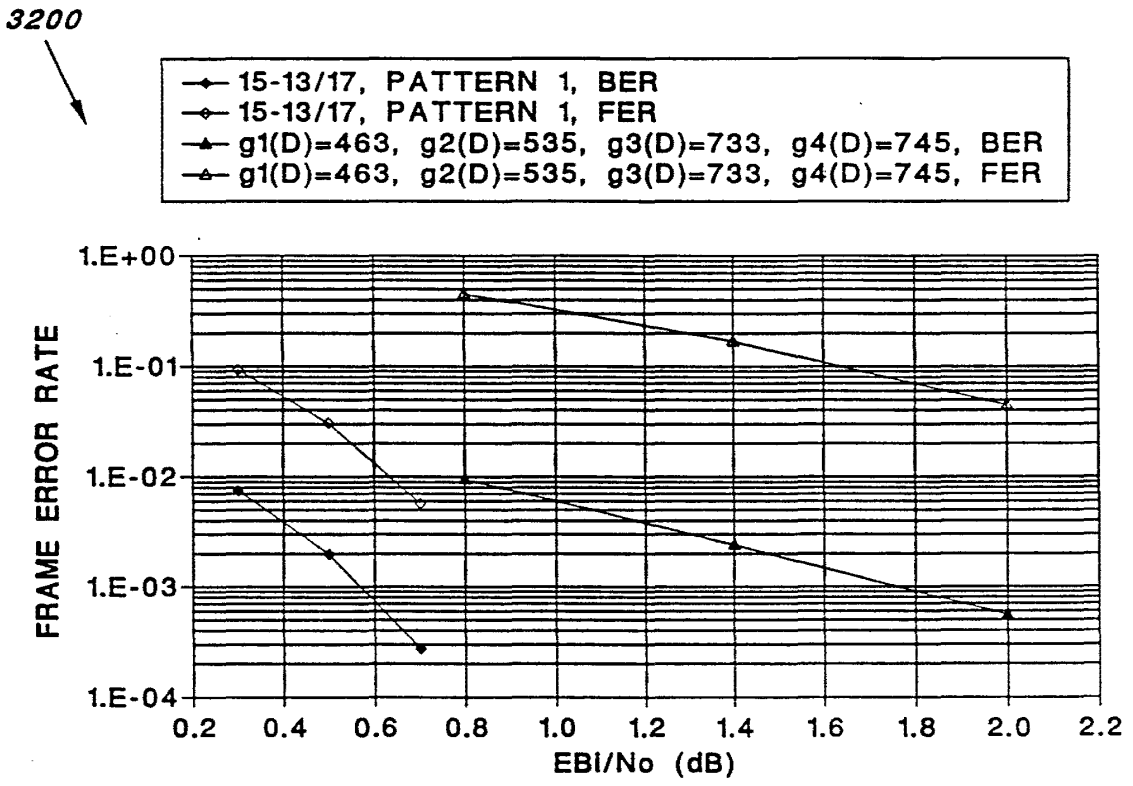


FIG. 32 COMPARISON OF RATE 1/4 FER-OPTIMIZED TURBO CODE VS CONVOLUTIONAL CODE, FRAME SIZE=512

INTERNATIONAL SEARCH REPORT

Inte ional Application No
PCT/US 99/02995

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L1/00 H04L1/12 H03M13/00

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)
IPC 7 H04L H03M

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 practical, 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.
A	ACIKEL O F ET AL: "High rate turbo codes for BPSK/QPSK channels" ICC '98. 1998 IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS. CONFERENCE RECORD. AFFILIATED WITH SUPERCOMM'98 (CAT. NO.98CH36220), ATLANTA, GA, USA, 7-11 JUNE 1998, pages 422-427 vol.1, XP002116627 1998, New York, NY, USA, IEEE, USA ISBN: 0-7803-4788-9 the whole document --- -/--	1-17

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"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)

"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

"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

"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

"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.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 September 1999	11/10/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Koukourlis, S

1

Form PCT/ISA/210 (second sheet) (July 1992)

IPR2023-01272 Page 301

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/US 99/02995

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	RIEDEL S: "SYMBOL-BY-SYMBOL MAP DECODING ALGORITHM FOR HIGH-RATE CONVOLUTIONALCODES THAT USE RECIPROCAL DUAL CODES" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, vol. 16, no. 2, 1 February 1998 (1998-02-01), pages 175-185, XP000741772 ISSN: 0733-8716 abstract page 184 - page 185, Appendix	1-17
A	DE 197 36 653 C (SIEMENS AG) 10 December 1998 (1998-12-10) column 3, line 27 - line 29 column 6, line 37 -column 7, line 48	1-17
A	WO 98 48517 A (GEN ELECTRIC) 29 October 1998 (1998-10-29) abstract	1-17

1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

IPR2023-01272 Page 302

INTERNATIONAL SEARCH REPORT

.ıformation on patent family members

Inte' onal Application No
PCT/US 99/02995

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 19736653 C	10-12-1998	AU 9253498 A WO 9911013 A	16-03-1999 04-03-1999
WO 9848517 A	29-10-1998	EP 0937337 A	25-08-1999

Form PCT/ISA/210 (patent family annex) (July 1992)

Electronic Patent Application Fee Transmittal

Application Number:	13744984
Filing Date:	18-Jan-2013
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:	John Porrazza/Carey Kulp
Attorney Docket Number:	I-2-0526US05

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:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt

EFS ID:	16233609
Application Number:	13744984
International Application Number:	
Confirmation Number:	9610
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:	John Porrazza/Carey Kulp
Filer Authorized By:	John Porrazza
Attorney Docket Number:	I-2-0526US05
Receipt Date:	03-JUL-2013
Filing Date:	18-JAN-2013
Time Stamp:	16:06:17
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$180
RAM confirmation Number	4807
Deposit Account	090435
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Transmittal Letter	IDS.pdf	45782 c357a824afa0ae8047dcb7ec44c72f1f82c6170d	no	3
Warnings:					
Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	sb08.pdf	633601 4cf76f5e0210597a2103a5b772cd664cecd97ed1	no	4
Warnings:					
Information:					
A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.					
3	Foreign Reference	KRPat.pdf	768313 fdc7ab607494a9a5906ea469ecb0334b441430de	no	16
Warnings:					
Information:					
4	Foreign Reference	wo0048353.pdf	5411566 eec86eb56c20ee01cffb06098658c7dc19820ea2	no	166
Warnings:					
Information:					
5	Other Reference-Patent/App/Search documents	KR_NOA.pdf	149403 ff7826b745ff657cd7b723107bb62107b9bfea38	no	3
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
6	Fee Worksheet (SB06)	fee-info.pdf	31041 af7c1cfc96882754badf8fc36c1176f141468a2b	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	7039706	

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.:	13/744,984
Confirmation No.:	9610
Filed:	January 18, 2013
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-2-0526US05
Date:	July 3, 2013

INFORMATION DISCLOSURE STATEMENT

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

Madam:

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 SB-08. Copies of the newly cited documents are enclosed.

This Application is a continuation of Non-Provisional Application No. 13/309,962, filed on December 2, 2011, which issued on January 22, 2013 as U.S. Patent No. 8,359,520, which is a continuation of Non-Provisional Application No. 11/974,381, filed on October 12, 2007, which issued on December 6, 2011 as U.S. Patent

No., which 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.

Pursuant to M.P.E.P § 609.04(a), since at least a portion of at least one item of information included in the Form SB-08 is not available in the English language, enclosed is an English translation of a communication from a foreign patent office, dated May 7, 2013.

This Information Disclosure Statement is being filed with the fee required by 37 C.F.R. § 1.17(p).

It is respectfully requested that the Examiner consider these documents and return an initialed copy of the Form SB-08 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 (4)

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

Courtesy Reminder for
Application Serial No: 13/744,984

Attorney Docket No: I-2-0526US05
Customer Number: 24374
Date of Electronic Notification: 06/07/2013

This is a courtesy reminder that new correspondence is available for this application. If you have not done so already, please review the correspondence. The official date of notification of the outgoing correspondence will be indicated on the form PTOL-90 accompanying the correspondence.

An email notification regarding the correspondence was sent to the following email address(es) associated with your customer number:
eoffice@volpe-koenig.com

To view your correspondence online or update your email addresses, please visit us anytime at **https://sportal.uspto.gov/secure/myportal/privatepair.** If you have any questions, please email the Electronic Business Center (EBC) at EBC@uspto.gov or call 1-866-217-9197.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/744,984	01/18/2013	Philip J. Pietraski	I-2-0526US05	9610

24374 7590 06/07/2013

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
06/07/2013	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. 13/744,984	Applicant(s) PIETRASKI ET AL.	
	Examiner FRITZ ALPHONSE	Art Unit 2112	AIA (First Inventor to File) Status No

-- 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 *3* 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 *18 January 2013*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

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

3)☐ 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.

4)☐ 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

5)☒ Claim(s) *1-14* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-14* is/are rejected.

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

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

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☒ The drawing(s) filed on *18 January 2013* 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).

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).

Certified copies:

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)).

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

Interim copies:

a)☐ All b)☐ Some c)☐ None of the: Interim copies of the priority documents have been received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *2/13/2013*.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

DETAILED ACTION

1. This Office Action is in regard to the application filed on 01/18/2013. Claims 1-14 are presented for examination.

Information Disclosure Statement

2. The Information Disclosure Statement (IDS) submitted is in compliance with the provisions of 37 CFR 1.97. Accordingly, the information disclosure statement has been considered by the examiner.

Oath/Declaration

3. The Oath/Declaration filed on 04/05/2013 is accepted.

Claim Rejections - 35 USC § 101

4. 35 U.S.C. 101 reads as follows:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

5. Claims 1-7, 13-14 are rejected under 35 U.S.C. 101 because the claimed invention is directed to non-statutory subject matter.

Claim 1 is rejected under 35 U.S.C. 101 as not falling within one of the four statutory categories of invention. While the claim recites a series of steps or acts to be performed, there is an insufficient recitation of a machine or transformation. The involvement of machine, or transformation, with the steps is merely nominally, insignificantly, or tangentially related to the performance of the steps, e.g., data gathering, or merely recites a field in which the method is intended to be applied.

Double Patenting

6. The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or

improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory obviousness-type double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent either is shown to be commonly owned with this application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement.

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

7. Claims 1-7, 13-14 and 8-12 are rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-3 and 4-8 of U.S. Patent No. 8,074,143. Although the conflicting claims are not identical, they are not patentably distinct from each other

because claims 1-14 of the present application are substantially equivalent to claims 1-8 of U.S. Patent No. 8,074,143.

Conclusion

8. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. See PTO-892.

9. 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, Albert Decady, can be reached at (571) 272-3819.

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. 13/744,984	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-6,370,669	04-2002	Eroz et al.	714/774
*	B	US-6,397,367	05-2002	Park et al.	714/786
*	C	US-6,622,281	09-2003	Yun et al.	714/790
*	D	US-6,665,833	12-2003	Tong et al.	714/790
	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.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13744984	PIETRASKI ET AL.
	Examiner	Art Unit
	FRITZ ALPHONSE	2112

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
714	790,774,786,752,755,800	6/1/2013	FA

SEARCH NOTES		
Search Notes	Date	Examiner
East Search	6/1/2013	FA
Plus Search (See East Search)	6/1/2013	FA

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

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

06/01/2013

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-2-0526US05	SERIAL NO. 13/744,984
	APPLICANT Pietraski et al.	
	FILING DATE January 18, 2013	GROUP 2112

U.S. PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
/F.A./		6,266,795	07/2001	Wei			
		6,370,669	04/2002	Eroz et al.			
		6,397,367	05/2002	Park et al.[5]			
	*	6,476,734	11/2002	Jeong et al.[7]			
		6,601,214	07/2003	Hammons, Jr.			
		6,622,281	09/2003	Yun et al.[6]			
		6,631,491	10/2003	Shibutani et al.			
		6,665,813	12/2003	Forsman et al.			
	*	6,744,744	06/2004	Tong et al.[8]			
		6,845,482	01/2005	Yao et al.			
		7,028,230	04/2006	Manninen et al.			
		7,076,726	07/2006	Yun et al.			
		7,089,450	08/2006	Anderson et al.			
		7,295,625	11/2007	Doetsch 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
/F.A./		00/065446	06/2005	WO				
/F.A./		00/011791	03/2000	WO[1]				
/F.A./		00/041343	07/2000	WO[2]				
/F.A./		02/033910	04/2002	WO[3]				
/F.A./		03/069784	08/2003	WO[4]				

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.

2216503-1

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-2-0526US05	SERIAL NO. 13/744,984
	APPLICANT Pietraski et al.	
	FILING DATE January 18, 2013	GROUP 2112

OTHER DOCUMENTS		
EXAMINER INITIAL		DESCRIPTION (Including Author, Title, Date, Pertinent Pages, Etc.)
/F.A./		"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).
/F.A./		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).
/F.A./		Mo et al., "Analysis of Puncturing Pattern for High Rate Turbo Codes," IEEE International, 0-7803-5538-5/99, 1999, pgs. 547-550.
/F.A./		NORTEL NETWORKS, "Proposal for Rate Matching for Turbo Codes," pp. 1-5 (May 12, 1999).
/F.A./		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).
/F.A./		SIEMENS, "Turbo Coder Irregularities In HSDPA", 3GPP TSG-RAN Working Group 1 #32, Toc R1-030421, (Paris, France 19-23 May 2003).
/F.A./		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).
/F.A./		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).
/F.A./		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).
/F.A./		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).
/F.A./		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; MAC Protocol Specification (Release 5)", 3GPP TS 25.321 V5.2.0 (September 2002).

EXAMINER /Fritz Alphonse/	DATE CONSIDERED 06/01/2013

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.

2216503-1

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-2-0526US05	SERIAL NO. 13/744,984
	APPLICANT Pietraski et al.	
	FILING DATE January 18, 2013	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 4)", 3GPP TS 25.321 V4.9.0 (September 2003).
/F.A./		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; MAC Protocol Specification (Release 4)", 3GPP TS 25.321 V4.6.0 (September 2002).
/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).
/F.A./		THIRD GENERATION PARTNERSHIP PROJECT, "Technical Specification Group Radio Access Network; MAC Protocol Specification (Release 1999)", 3GPP TS 25.321 V3.13.0 (September 2002).
/F.A./		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).
/F.A./		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).
/F.A./		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).
/F.A./		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).
/F.A./		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).
/F.A./		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).
/F.A./		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).
/F.A./		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).

EXAMINER /Fritz Alphonse/	DATE CONSIDERED 06/01/2013

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	APPLICANT Pietraski et al.	
	FILING DATE January 18, 2013	GROUP 2112

EXAMINER INITIAL		DESCRIPTION (Including Author, Title, Date, Pertinent Pages, Etc.)
/F.A./		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).
/F.A./		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).
/F.A./		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).
/F.A./		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).
/F.A./		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; [6] Equivalent to DE 1030407; [7] Equivalent to JP 2002-164948; [8] Equivalent to JP 2001-057521.

EXAMINER /Fritz Alphonse/	DATE CONSIDERED 06/01/2013

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.

2216503-1

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	233	(rate matching interleav$4 bit stream)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/29 11:38
S2	0	(buffer$4 interleav bit stream virtual buffer)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/29 11:40
S3	31	(buffer$4 interleav$4 bit stream virtual buffer)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/29 11:40
S4	19	S1 S3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/05/29 11:40
S5	9124	virtual near4 buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/31 23:09
S6	0	virtual adj buffer is a physical adj buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/31 23:24
S7	92	virtual adj buffer same physical adj buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/05/31 23:24
S8	14	(rate matching interleav$4 bit stream	US-PGPUB;	SAME	OFF	2013/05/31

		buffer$4 virtual buffer)	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			23:45
S9	162	("20020051501" "6088387" "6028897" "6014411" "6044116" "6370669" "6397367" "6622281" "6665833" "6697986" "6744744" "6807238" "6816556" "6829305" "6892342" "6903665" "7016427" "7016658" "7027782" "7072307" "7089480" "7146552" "7165209" "7200792" "7210089" "7251285" "7280609" "7283509" "7293217" "7415263" "7421033" "7458011" "7483389" "7496079" "7523383" "7536624" "7620872" "7640486" "7673213" "7676731" "7676732" "7743312" RE41498 "7782973" "7802164" "7814390" "7814391" "7827466" "7925963" "7958425" "7987414" "8074143" "7925963" "7958425" "7987414" "8074143" "8250429" "8254284" "8275032" "8359520" "8386877" "8416794" "20010009569" "20010010710" "20010034209" "20020015419" "20020027956" "20020166093" "20030007476" "20030021240" "20030031233" "20030076870" "20030097629" "20030120995" "20030135811" "20030171121" "20040125765" "20040139378" "20040146029" "20040184553" "20040187069" "20040187070" "20040257992" "20050053168" "20050100085" "20050100103" "20050172201" "20050172202" "20050204251" "20050216819" "20050283710" "20060031737" "20060150051" "20060179401" "20060190801" "20060206781" "20060239237" "20060251001" "20070089025" "20070101232").pn.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:13
S10	14	(rate matching interleav$4 bit stream buffer$4 virtual buffer)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/06/01 13:16
S11	92	virtual adj buffer same physical adj buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/06/01 13:17
S12	0	S9 S10 S11	US-PGPUB; USPAT; USOCR; FPRS;	AND	OFF	2013/06/01 13:17

			EPO; JPO; DERWENT; IBM_TDB			
S13	76	S9 and rate near4 matching	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/01 13:27
S14	47	S13 and interleav$4 bit near4 stream	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/01 13:27
S15	1	S14 and buffer$4 interleav$4 bit stream	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/06/01 13:29
S16	1	S9 and buffer$4 interleav$4 bit stream	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	SAME	OFF	2013/06/01 13:50
S17	1	S10 S14	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	AND	OFF	2013/06/01 13:51
S18	0	S9 and S11	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:51
S19	76	S9 and S13	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:51
S20	0	S19 and mate same matching	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:58
S21	76	S19 and rate same matching	US-PGPUB; USPAT;	OR	OFF	2013/06/01 13:58

			USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			
S22	7177	"16" and virtual near4 buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:58
S23	11	S21 and virtual near4 buffer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 13:58
S24	44	S13 and "714"/$.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2013/06/01 14:11

6/ 1/ 2013 7:17:31 PM
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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13744984	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	06/01/2013								
	1	✓								
	2	✓								
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	11	✓								
	12	✓								

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/744,984	01/18/2013	Philip J. Pietraski	I-2-0526US05

CONFIRMATION NO. 9610

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

PUBLICATION NOTICE

OC00000061596145

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

Publication No.US-2013-0139040-A1
Publication Date:05/30/2013

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.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

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Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PLUS Search Results for S/N 13744984, Searched Tue May 28 15:12:12 EDT 2013

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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PLUS Search Results for S/N 13744984, Searched Fri Apr 26 15:08:38 EDT 2013

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I-2-0526US05

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

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

As the below named inventor, I hereby declare that:

This declaration is directed to:

☐ The attached application, or

☒ United States application or PCT international application number 13/744,984

filed on January 18, 2013.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I have reviewed and understand the contents of the above-identified application, including the claims.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in 37 CFR 1.56.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

LEGAL NAME OF INVENTOR

Inventor: Philip J. Pietraski Date: 4-2-2013

Signature:

Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. 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.

I-2-0526US05

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

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

As the below named inventor, I hereby declare that:

This declaration is directed to: ☐ The attached application, or

☒ United States application or PCT international application number 13/744,984

filed on January 18, 2013.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I have reviewed and understand the contents of the above-identified application, including the claims.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in 37 CFR 1.56.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

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LEGAL NAME OF INVENTOR

Inventor: Gregory S. Sternberg Date: 26 March 2013

Signature:

Note: An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. 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.

2215571-1

Electronic Acknowledgement Receipt

EFS ID:	15446576
Application Number:	13744984
International Application Number:	
Confirmation Number:	9610
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:	Baha A. Obeidat/Patricia Petaccia
Filer Authorized By:	Baha A. Obeidat
Attorney Docket Number:	I-2-0526US05
Receipt Date:	05-APR-2013
Filing Date:	18-JAN-2013
Time Stamp:	15:31:05
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	Oath or Declaration filed	20130405_I_2_526US05_Declaration.PDF	143955 e7ee76fc5b08bce206e10119d9980d6bd582727f	no	2
Warnings:					
Information:					

Total Files Size (in bytes):	143955

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.

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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
13/744,984	01/18/2013	2112	1390	I-2-0526US05	14	2

CONFIRMATION NO. 9610

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

FILING RECEIPT

OC000000059223387

Date Mailed: 02/19/2013

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

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

Applicant(s)

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

Assignment For Published Patent Application

INTERDIGITAL TECHNOLOGY CORPORATION, Wilmington, DE

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 13/309,962 12/02/2011 PAT 8359520 *
which is a CON of 11/974,381 10/12/2007 PAT 8074143
which is a CON of 10/725,779 12/02/2003 PAT 7293217
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
(*)Data provided by applicant is not consistent with PTO records.

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access - A proper **Authorization to Permit Access to Application by Participating Offices** (PTO/SB/39 or its equivalent) has been received by the USPTO.

If Required, Foreign Filing License Granted: 02/09/2013

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/744,984**

Projected Publication Date: 05/30/2013

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

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Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

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countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

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Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/744,984	01/18/2013	Philip J. Pietraski	I-2-0526US05

CONFIRMATION NO. 9610

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

NOTICE

OC000000059223388

Date Mailed: 02/19/2013

INFORMATIONAL NOTICE TO APPLICANT

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):
  ALL
  Applicant may submit the inventor's oath or declaration at any time before the Notice of Allowance and Fee(s) Due, PTOL-85, is mailed.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 13/744,984

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	390
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	620
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	250
TOTAL CLAIMS (37 CFR 1.16(i))	14 minus 20 =	*			OR	x 62 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2 minus 3 =	*				x 250 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 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).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1260

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))							OR		
						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	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
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))							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 found in the appropriate box in column 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-2-0526US05	SERIAL NO. 13/744,984
	APPLICANT Pietraski et al.	
	FILING DATE January 18, 2013	GROUP 2112

U.S. PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
		6,266,795	07/2001	Wei			
		6,370,669	04/2002	Eroz et al.			
		6,397,367	05/2002	Park et al.[5]			
	*	6,476,734	11/2002	Jeong et al.[7]			
		6,601,214	07/2003	Hammons, Jr.			
		6,622,281	09/2003	Yun et al.[6]			
		6,631,491	10/2003	Shibutani et al.			
		6,665,813	12/2003	Forsman et al.			
	*	6,744,744	06/2004	Tong et al.[8]			
		6,845,482	01/2005	Yao et al.			
		7,028,230	04/2006	Manninen et al.			
		7,076,726	07/2006	Yun et al.			
		7,089,450	08/2006	Anderson et al.			
		7,295,625	11/2007	Doetsch 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[1]				
		00/041343	07/2000	WO[2]				
		02/033910	04/2002	WO[3]				
		03/069784	08/2003	WO[4]				

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.

2216503-1

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-2-0526US05	SERIAL NO. 13/744,984
	APPLICANT Pietraski et al.	
	FILING DATE January 18, 2013	GROUP 2112

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.
		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).
		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).

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.

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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-2-0526US05	SERIAL NO. 13/744,984
	APPLICANT Pietraski et al.	
	FILING DATE January 18, 2013	GROUP 2112

EXAMINER INITIAL		DESCRIPTION (Including Author, Title, Date, Pertinent Pages, Etc.)
		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).
		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).

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.

2216503-1

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-2-0526US05	SERIAL NO. 13/744,984
	APPLICANT Pietraski et al.	
	FILING DATE January 18, 2013	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 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).

[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; [6] Equivalent to DE 1030407; [7] Equivalent to JP 2002-164948; [8] Equivalent to JP 2001-057521.

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.

2216503-1

Electronic Acknowledgement Receipt

EFS ID:	14951338
Application Number:	13744984
International Application Number:	
Confirmation Number:	9610
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:	John Porrazza/Carey Kulp
Filer Authorized By:	John Porrazza
Attorney Docket Number:	I-2-0526US05
Receipt Date:	13-FEB-2013
Filing Date:	18-JAN-2013
Time Stamp:	16:03:21
Application Type:	Utility under 35 USC 111(a)

Payment information:

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File Listing:

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2	Information Disclosure Statement (IDS) Form (SB08)	PTO1440.pdf	59251 ce635615a40b50745d4a229c4b3cf0d39956150e	no	4

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the PATENT APPLICATION of:	
	Pietraski et al.
Application No.:	13/744,984
Confirmation No.:	9610
Filed:	January 18, 2013
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-2-0526US05
Date:	February 13, 2013

INFORMATION DISCLOSURE STATEMENT

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

Madam:

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 Non-Provisional Application No. 13/309,962, filed on December 2, 2011, which issued on January 22, 2013 as U.S. Patent No. 8,359,520, which is a continuation of Non-Provisional Application No. 11/974,381, filed on October 12, 2007, which issued on December 6, 2011 as U.S. Patent

No., which 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.

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 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.

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,

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Enclosure

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

[0001] CROSS REFERENCE TO RELATED APPLICATIONS

[0002] This application is a continuation of U.S. Patent Application Serial No. 13/309,962, filed on December 2, 2011, which is a continuation of U.S. Patent Application Serial No. 11/974,381 filed on October 12, 2007, which issued as U.S. Patent No. 8,074,143 on December 6, 2011; which is a continuation of U.S. Patent Application Serial No. 10/725,779, filed on December 2, 2003, which issued as U.S. Patent No. 7,293,217 on 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 herein as if fully set forth herein.

[0003] FIELD OF THE INVENTION

[0004] 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.

[0005] BACKGROUND

[0006] 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.

[0007] 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.

[0008] 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.

[0009] 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.

[0010] 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).

[0011] 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.

[0012] 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.

[0013] Figures 5A, 5B and 6 are diagrams of channel coding and multiplexing examples in accordance with 3GPP Frequency Division Duplex (FDD) specifications.

[0014] 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.

[0015] 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.

[0016] 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.

[0017] 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.

[0018] 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.

[0019] 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.

[0020] 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.

[0021] 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.

[0022] 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.

[0023] 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.

[0024] 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.

[0025] 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.

[0026] 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.

[0027] It would be desirable to have a method for creating high-rate Turbo codes that avoids problematic interactions by modifying the puncturing patterns.

[0028] SUMMARY OF THE INVENTION

[0029] 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.

[0030] 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.

[0031] 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.

[0032] 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).

[0033] BRIEF DESCRIPTION OF THE DRAWINGS

[0034] 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:

[0035] Figure 1 is a schematic diagram of a typical CDMA system in accordance with current 3GPP specifications;

[0036] Figure 2 is a processing diagram of TrCH data for a CCTrCH in accordance with 3GPP TDD specifications;

[0037] Figures 3 and 4 are diagrams of channel coding and multiplexing examples in accordance with 3GPP TDD specifications;

[0038] Figures 5A, 5B and 6 are diagrams of channel coding and multiplexing examples in accordance with 3GPP FDD specifications;

[0039] 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;

[0040] 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;

[0041] 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;

[0042] Figure 10 is a schematic block diagram showing a circuit for 3GPP rate matching for HSDPA, using a Turbo coded HS-DSCH; and

[0043] Figure 11 graphically depicts initial Block Error Rate (BLER) for HS-DSCH transport blocks with certain effective coding rates.

[0044] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0045] 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.

[0046] 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.

[0047] 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.

[0048] 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.

[0049] 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.

[0050] 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.

[0051] 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.

[0052] 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.

[0053] 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.

[0054] 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.

[0055] 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,

$$\hat{N} = \left\lfloor\frac{4I}{7P} + \frac{1}{2}\right\rfloor. \qquad \text{Equation 2}$$

[0056] In biasing the puncturing rates of the parity bit streams 1 and 2, P1 and P2, two constraints must be met.

[0057] 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.

[0058] These two constraints can be combined in to the following expression for Δ, where:

[0059] $$\Delta = \left\lceil \max\left\{ \frac{I}{\left\lfloor \frac{7\hat{N}-1}{2} \right\rfloor} - \frac{P}{2}, \frac{P}{2} - \frac{I}{\left\lceil \frac{7\hat{N}+1}{2} \right\rceil} \right\} \right\rceil \quad \text{Equation 3}$$

[0060] 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.

[0061] 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.

[0062] 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 performance. Since code rates with degraded performance can now be identified using the above equation, it is a simple matter to avoid them.

[0063] 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.

[0064] 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.

[0065] 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.

[0066] 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.

[0067] 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.

[0068] 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.

[0069] 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.

[0070] 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.

[0071] 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.

[0072] 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.

[0073] 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.

[0074] 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.

[0075] 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.

[0076] 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.

[0077] 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.

[0078] The code rates at the center of these regions are determined by:

[0079] $$CR = \frac{1}{1+\frac{2}{3.5N}} = \frac{3.5N}{3.5N+2} \qquad N = 1,2,... \qquad \text{Equation 4}$$

[0080] 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,....

[0081] 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.

[0082] 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.

[0083] 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.

$$\begin{aligned}\lambda(r1,r2)=\sum_{n=1}^{L-1}\alpha_n\Bigg[&\left(1-\left\lceil\frac{1}{L}\lceil r1\lceil nr2\rceil\rceil-\left\lfloor\frac{1}{L}\lceil r1\lceil nr2\rceil\rceil\right\rfloor\right\rceil\right)(nr2-\lfloor r2\rfloor)(r1\lceil nr2\rceil-\lfloor r1\lceil nr2\rceil\rfloor)+\\&\left(1-\left\lceil\frac{1}{L}\lfloor r1\lceil nr2\rceil\rfloor-\left\lfloor\frac{1}{L}\lfloor r1\lceil nr2\rceil\rfloor\right\rfloor\right\rceil\right)(nr2-\lfloor nr2\rfloor)(-r1\lceil nr2\rceil-\lfloor r1\lceil nr2\rceil\rfloor+1)+\\&\left(1-\left\lceil\frac{1}{L}\lceil r1\lfloor nr2\rfloor\rceil-\left\lfloor\frac{1}{L}\lceil r1\lfloor nr2\rfloor\rceil\right\rfloor\right\rceil\right)(-nr2+\lfloor nr2\rfloor+1)(r1\lfloor nr2\rfloor-\lfloor r1\lfloor nr2\rfloor\rfloor)+\\&\left(1-\left\lceil\frac{1}{L}\lfloor r1\lfloor nr2\rfloor\rfloor-\left\lfloor\frac{1}{L}\lfloor r1\lfloor nr2\rfloor\rfloor\right\rfloor\right\rceil\right)(-nr2+\lfloor nr2\rfloor+1)(-r1\lfloor nr2\rfloor+\lfloor r1\lfloor nr2\rfloor\rfloor+1)\Bigg]\end{aligned}$$

Equation 5

[0084] 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.

[0085] 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.

[0086] 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.

[0087] 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.

[0088] 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.

[0089] 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.

[0090] 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.

[0091] 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.

[0092] 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.

[0093] 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.

[0094] 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.

[0095] 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.

[0096] 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.

[0097] 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.

[0098] 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.

[099] The present invention is particularly useful for 3GPP-coding, and can be used for low chip rate TDD, high chip rate TDD and FDD.

[0100] 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.

[0101] 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.

[0102] 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.

[0103] 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.

[0104] 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.

[0105] 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.

[0106] 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.

[0107] 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.

[0108] 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%.

[0109] 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.

[0110] 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.

[0111] 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.

[0112] 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.

[0113] 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.

[0114] 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.

[0115] 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).

[0116] 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.

[0117] 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.

[0118] 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.

[0119] 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.

[0120] 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.

[0121] 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).

[0122] 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.

[0123] At least two alternative approaches exist to avoid the problematic interactions between Turbo-coder output and puncturing in the rate-matching stages.

[0124] 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.

[0125] 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.

[0126] 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.

[0127] 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.

[0128] 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.

[0129] Described below is one embodiment of the present invention that includes a combination of previously described techniques.

[0130] 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.

[0131] The hybrid ARQ functionality consists of two rate-matching stages and a virtual buffer.

[0132] 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.

[0133] 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.

[0134] 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.

[0135] The HARQ bit separation function shall be performed in the same way as bit separation for turbo encoded TrCHs.

[0136] HARQ first stage rate matching for the HS-DSCH transport channel shall be performed using the method described below with the following specific parameters.

[0137] 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.

[0138] 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.

[0139] 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.

[0140] 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 $(\alpha \le 4)$

$$round = \frac{\left\lfloor 7 \cdot \alpha \cdot PR + \frac{1}{2} \right\rfloor}{7 \cdot \alpha}$$

$$\lambda = PR - round$$

if $\left(|\lambda| > \frac{1}{\delta_{PR}} \right) or \left(PR > \frac{48}{49} \right) or \left(PR < \frac{1}{49} \right)$ 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

[0141] 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.

[0142] For each radio frame, the rate-matching pattern shall be calculated, where:

X_i is as above,

$e_{ini} = X_i$

$e_{plus} = a \times X_i$

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

[0143] HARQ second stage rate matching for the HS-DSCH transport channel shall be done using one of two possible methods.

[0144] 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.

[0145] Composite Puncturing Ratio, $CPR = \begin{cases} \dfrac{\lfloor N^{TTI}/3 \rfloor - N_{t,p1}}{N^{TTI}/3}, b = 2 \\ \dfrac{\lfloor N^{TTI}/3 \rfloor - N_{t,p2}}{N^{TTI}/3}, b = 3 \end{cases}$

[0146] 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.

[0147] 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.

[0148] 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.

[0149] 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.

[0150] 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 $N_{t,sys} = \left\lfloor N_{sys} \cdot \frac{N_{data}}{N_{sys} + 2N_{p1}} \right\rfloor$.

[0151] 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

[0152] 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 $r_{max} = 4$.

[0153] 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).

[0154] 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.

[0155] 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.

[0156] 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 $X_{seg1} = 42 \cdot \lfloor X_i / 98 \rfloor$, $X_{seg2} = 56 \cdot \lfloor X_i / 98 \rfloor$, $X_{seg3} = X_i \bmod 98$

[0157] 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 segment is empty, then of course no puncturing is performed on that non-existent segment.

[0158] Additional parameters for HARQ Second Rate Matching Stage for problematic puncturing rates

[0159] Parameters P, N_{data}, N_{sys}, N_{p1}, N_{p2}, $N_{p,t1}$, and $N_{p,t2}$ are calculated, additional parameters are defined below.

[0160] 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.

[0161] For $N_{data} \le N_{sys} + N_{p1} + N_{p2}$, puncturing is performed in the second rate matching stage.

[0162] The number of parity bits after segmentation is

$$N_{pb,seg1} = 42 \cdot \lfloor N_{pb} / 98 \rfloor$$
$$N_{pb,seg2} = 56 \cdot \lfloor N_{pb} / 98 \rfloor$$
$$N_{pb,seg3} = N_{pb} \bmod 98$$

[0163] The number of parity bits in each segment for parity 1 bits (b=2), and parity 2bits (b=3) is:

$$N_{t,pb,seg1} = \left\lfloor \frac{49 \cdot N_{t,pb} \cdot \lfloor N_{pb}/98 \rfloor}{N_{pb}} + \frac{1}{2} \right\rfloor;$$

$$N_{t,pb,seg2} = \left\lfloor \frac{49 \cdot N_{t,pb} \cdot \lfloor N_{pb}/98 \rfloor}{N_{pb}} + \frac{1}{2} \right\rfloor;$$

$$N_{t,pb,seg3} = N_{t,pb} - \left(N_{t,pb,seg1} + N_{t,pb,seg2}\right)$$

[0164] 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

[0165] 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 $r_{max} = 4$.

[0166] 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.

[0167] 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.

[0168] The re-concatenated bit stream is denoted by:

$$x_{o,seg1,1}, x_{o,seg1,2}, \ldots x_{o,seg1,N_{t,p1,seg1}}, x_{o,seg2,1}, x_{o,seg2,2}, \ldots x_{o,seg2,N_{t,p1,seg2}}, x_{o,seg3,1}, x_{o,seg3,2}, \ldots x_{o,seg3,N_{t,p1,seg3}}$$

[0169] 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.

[0170] Data is written into the interleaver column by column, and read out of the interleaver column by column starting from the first column.

[0171] $N_{t,sys}$ is the number of transmitted systematic bits. Intermediate values N_r and N_c are calculated using:

$$N_r = \left\lfloor \frac{N_{t,sys}}{N_{col}} \right\rfloor \text{ and } N_c = N_{t,sys} - N_r \cdot N_{col}.$$

[0172] If N_c=0 and $N_r > 0$, the systematic bits are written into rows 1...N_r.

[0173] 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.

[0174] 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.

[0175] 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.

[0176] 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 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.

[0177] 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.

[0178] 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.

[0179] In order to avoid either of these puncturing mechanisms that cause a performance degradation, the following methodology has been adopted:

[0180] 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.

[0181] 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.

[0182] 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.

[0183] 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.

[0184] 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.

[0185] 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.

[0186] 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.

[0187] 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 performing rate matching, the method comprising:

interleaving a first bit stream to produce an interleaved first bit stream;

interleaving a second bit stream to produce an interleaved second bit stream;

interleaving a third bit stream to produce an interleaved third bit stream;

buffering the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream in a virtual buffer; and

performing rate matching on at least one output of the virtual buffer.

2. The method of claim 1 wherein the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream are buffered on a condition that the number of bits of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream is not larger than a size of the virtual buffer.

3. The method of claim 2, further comprising:

buffering a portion of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream in the virtual buffer on a condition that the number of bits of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream is larger than a size of the virtual buffer.

4. The method of claim 3 wherein the buffered portion of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream includes all of the interleaved first bit stream.

5. The method of claim 1, further comprising:

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

6. The method of claim 1 performed by a wireless transmit/receive unit (WTRU).

7. The method of claim 1 performed by a node B.

8. An apparatus for performing rate matching, the apparatus comprising:

a first interleaver configured to interleave a first bit stream to produce an interleaved first bit stream;

a second interleaver configured to interleave a second bit stream to produce an interleaved second bit stream;

a third interleaver configured to interleave a third bit stream to produce an interleaved third bit stream;

a virtual buffer configured to buffer the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream; and

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

9. The apparatus of claim 8 wherein the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream are buffered on a condition that the number of bits of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream is not larger than a size of the virtual buffer.

10. The apparatus of claim 9 wherein the virtual buffer is further configured to buffer a portion of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream on a condition that the number of bits of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream is larger than a size of the virtual buffer.

11. The apparatus of claim 10 wherein the buffered a portion of the interleaved first bit stream, the interleaved second bit stream and the interleaved third bit stream includes all of the interleaved first bit stream.

12. The apparatus of claim 8, further comprising:

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

13. The apparatus of claim 7 configured as a wireless transmit/receive unit (WTRU).

14. The apparatus of claim 7 configured as a node B.

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.

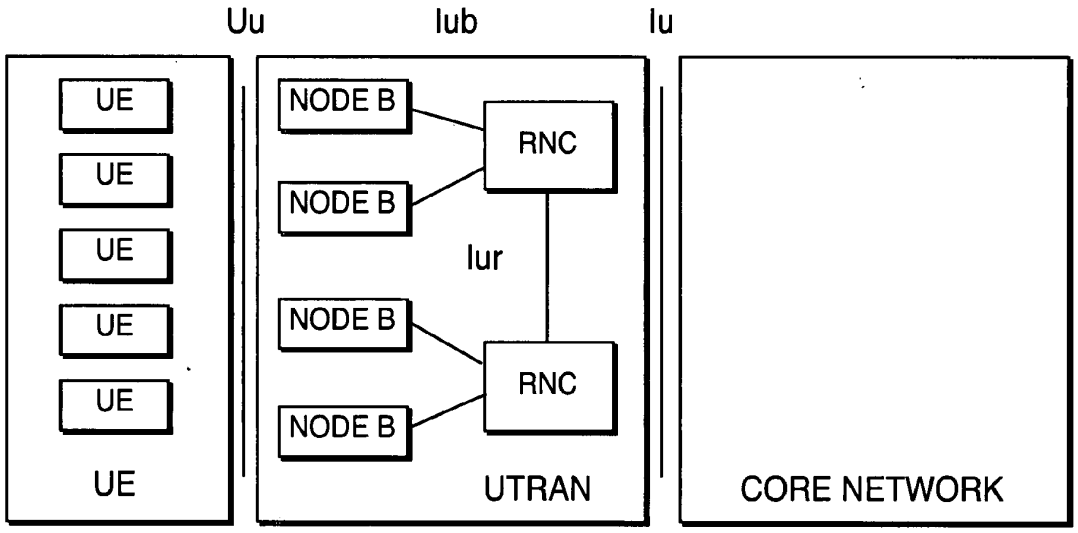


FIG. 1
PRIOR ART

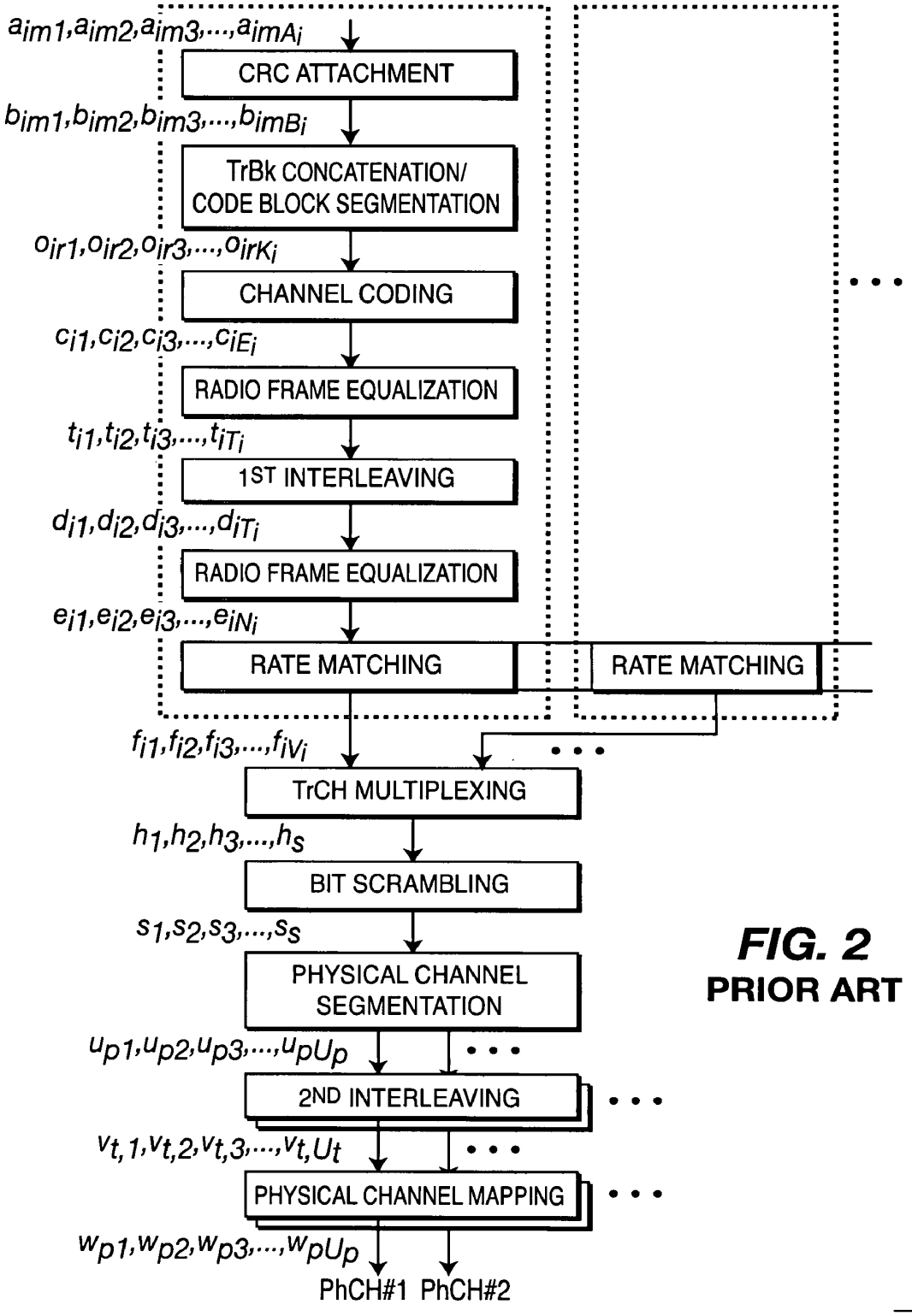


FIG. 2
PRIOR ART

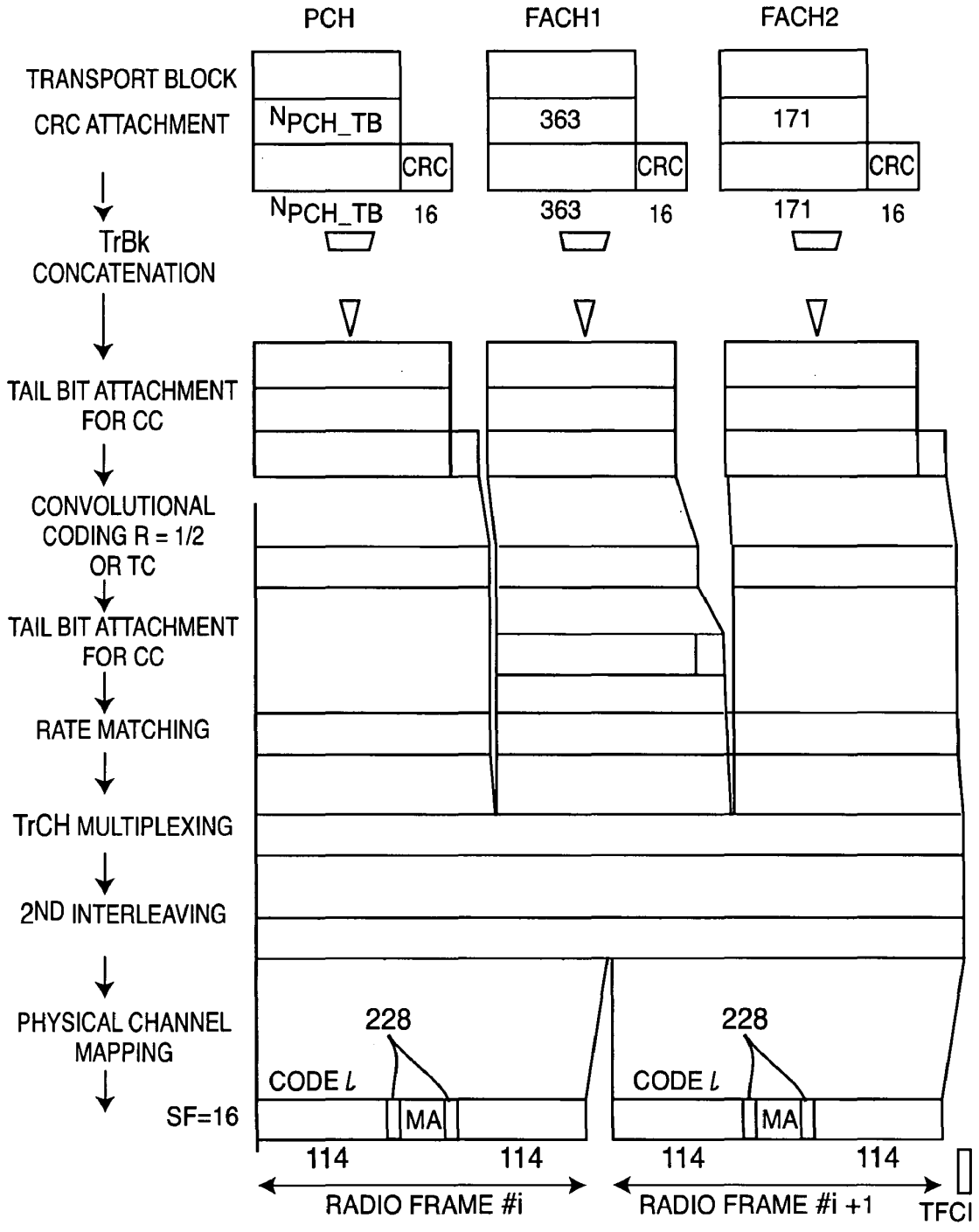


FIG. 3
PRIOR ART

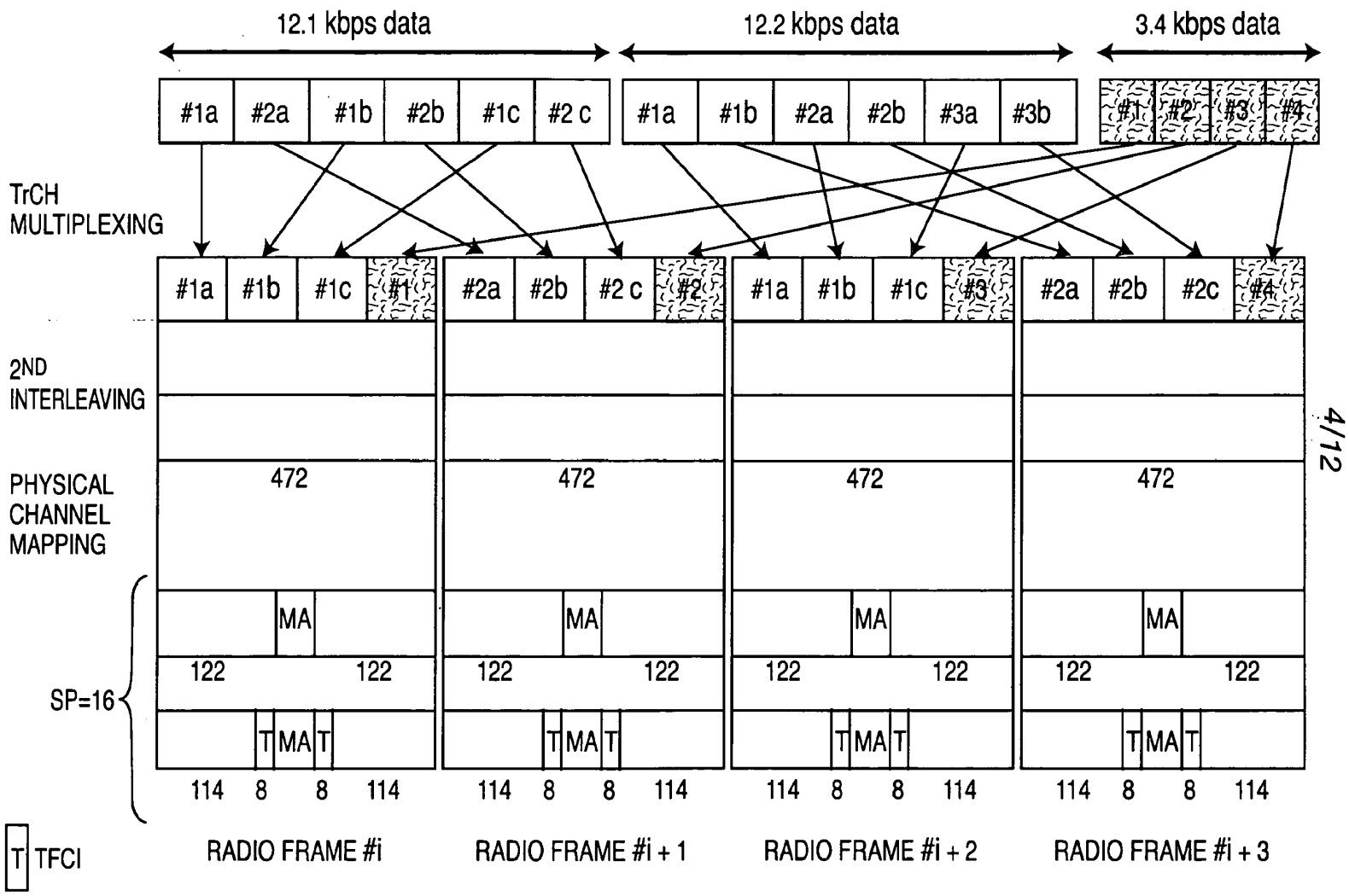


FIG. 4 PRIOR ART

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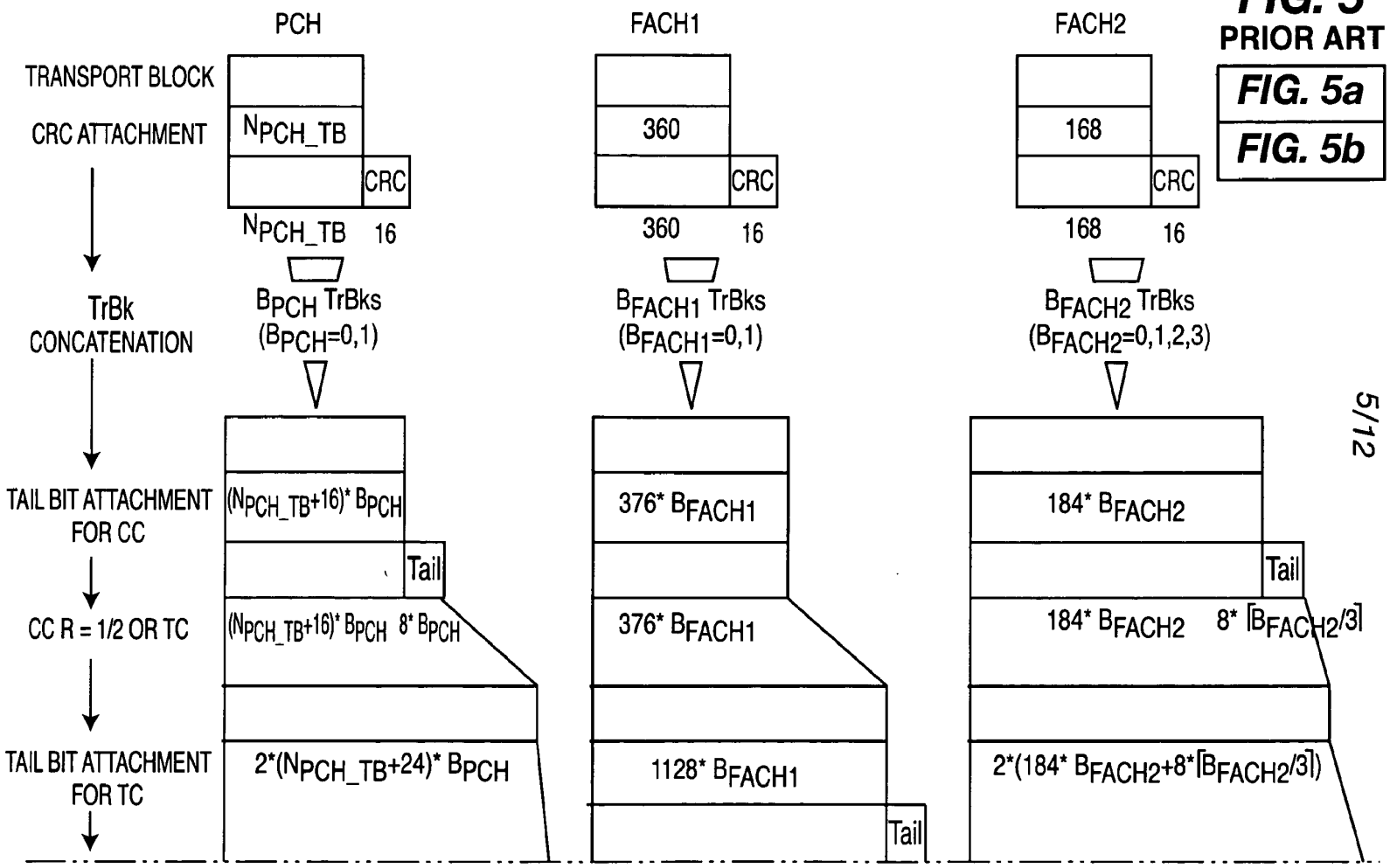


FIG. 5
PRIOR ART

FIG. 5a
FIG. 5b

5/12

FIG. 5a

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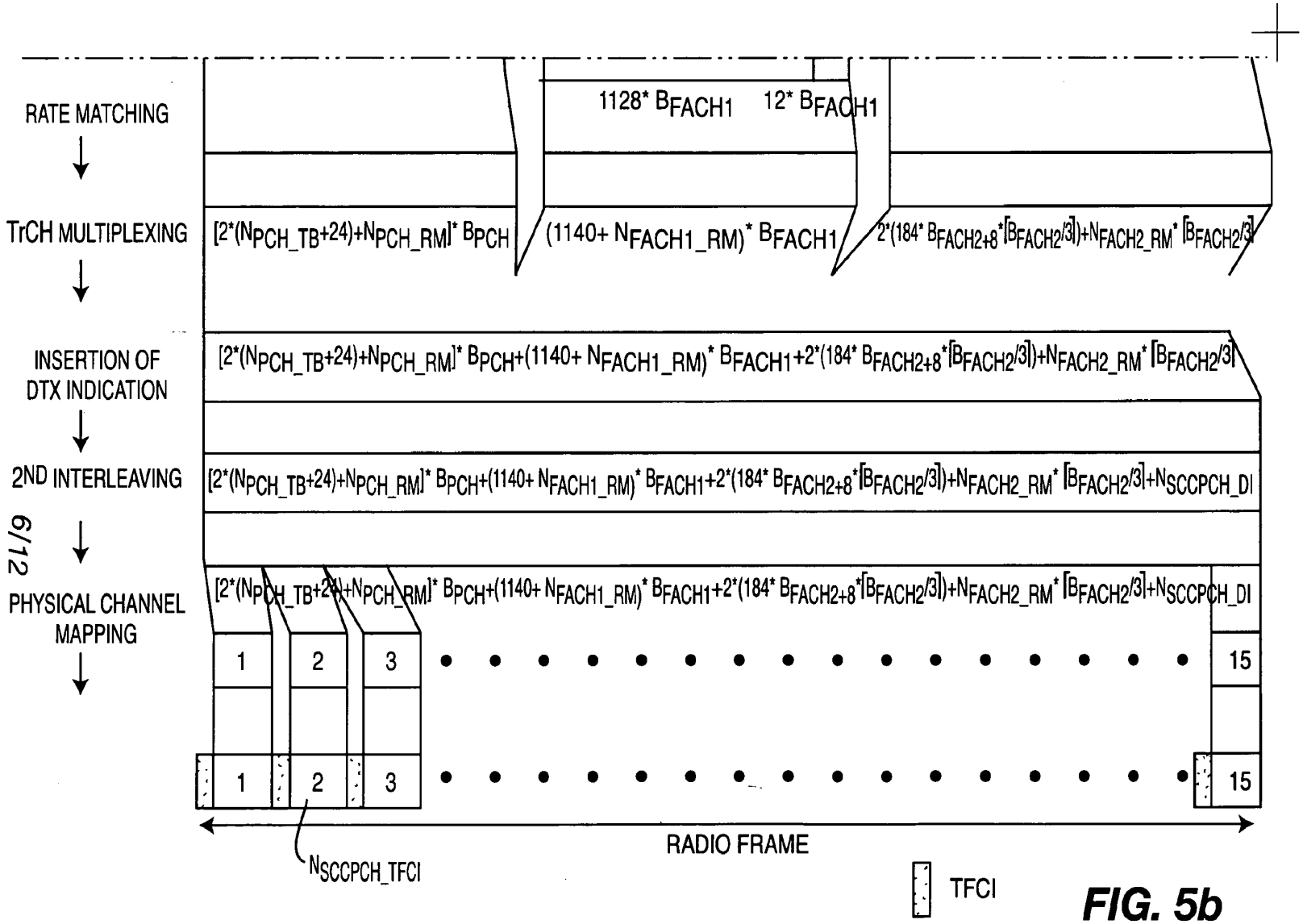

RATE MATCHING
TrCH MULTIPLEXING
INSERTION OF DTX INDICATION
2ND INTERLEAVING
PHYSICAL CHANNEL MAPPING
1128* BFACH1
12* BFACH1
[2*(NPCH_TB+24)+NPCH_RM]* BPCH
(1140+ NFACH1_RM)* BFACH1
2*(184* BFACH2+8*⌈BFACH2/3⌉)+NFACH2_RM* ⌈BFACH2/3⌉
[2*(NPCH_TB+24)+NPCH_RM]* BPCH+(1140+ NFACH1_RM)* BFACH1+2*(184* BFACH2+8*⌈BFACH2/3⌉)+NFACH2_RM* ⌈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

6/12

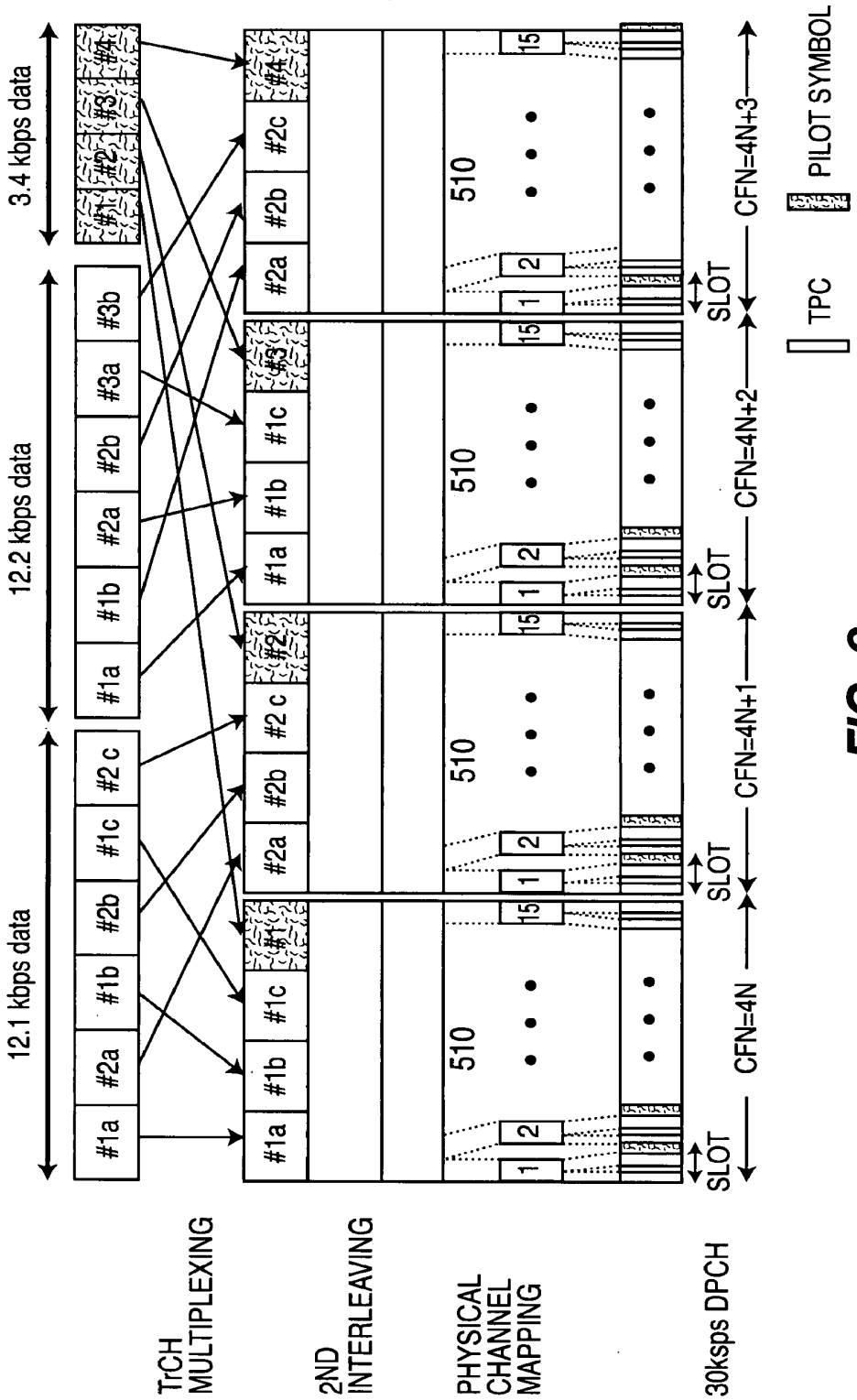


FIG. 6
PRIOR ART

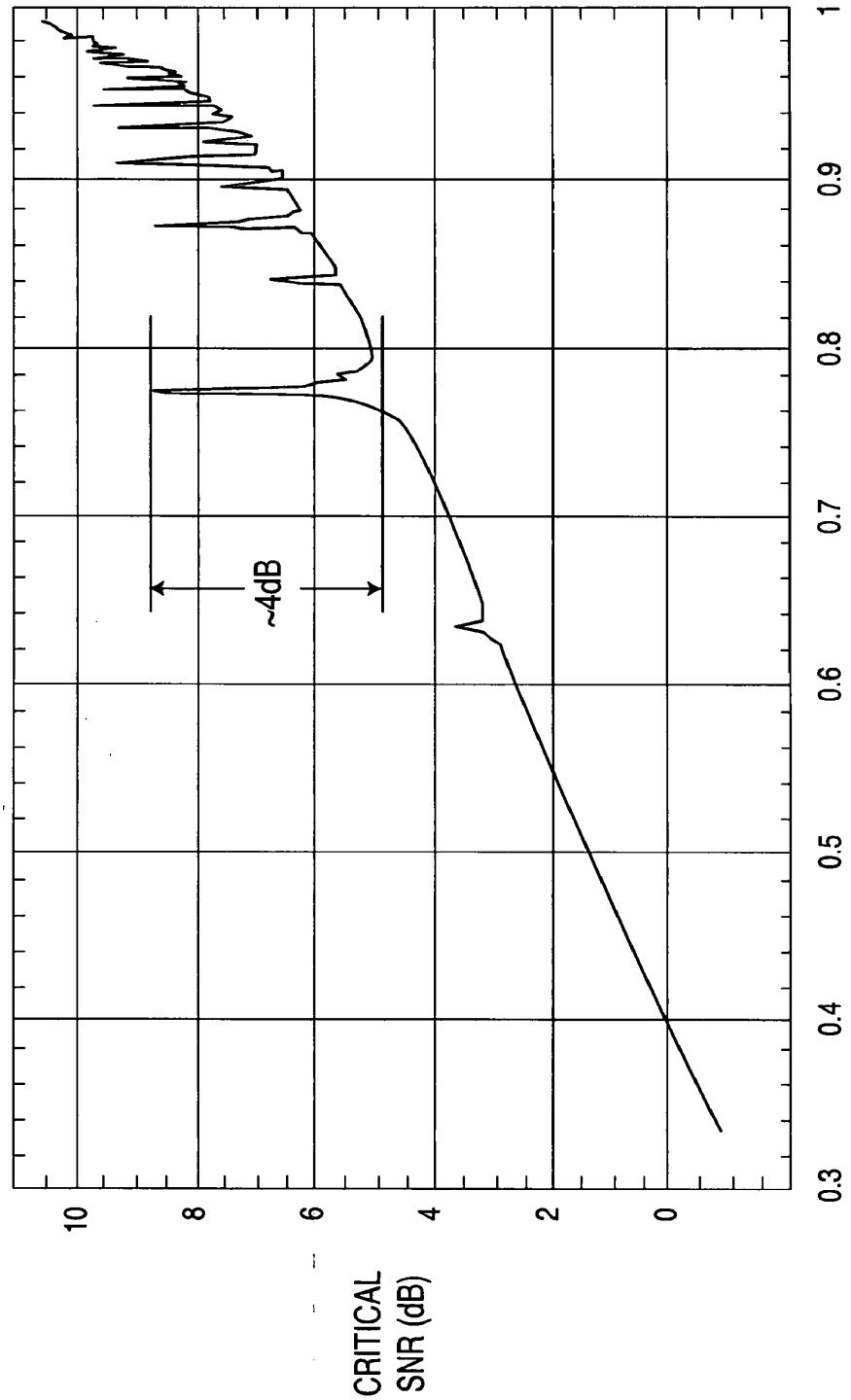


FIG. 7
PRIOR ART

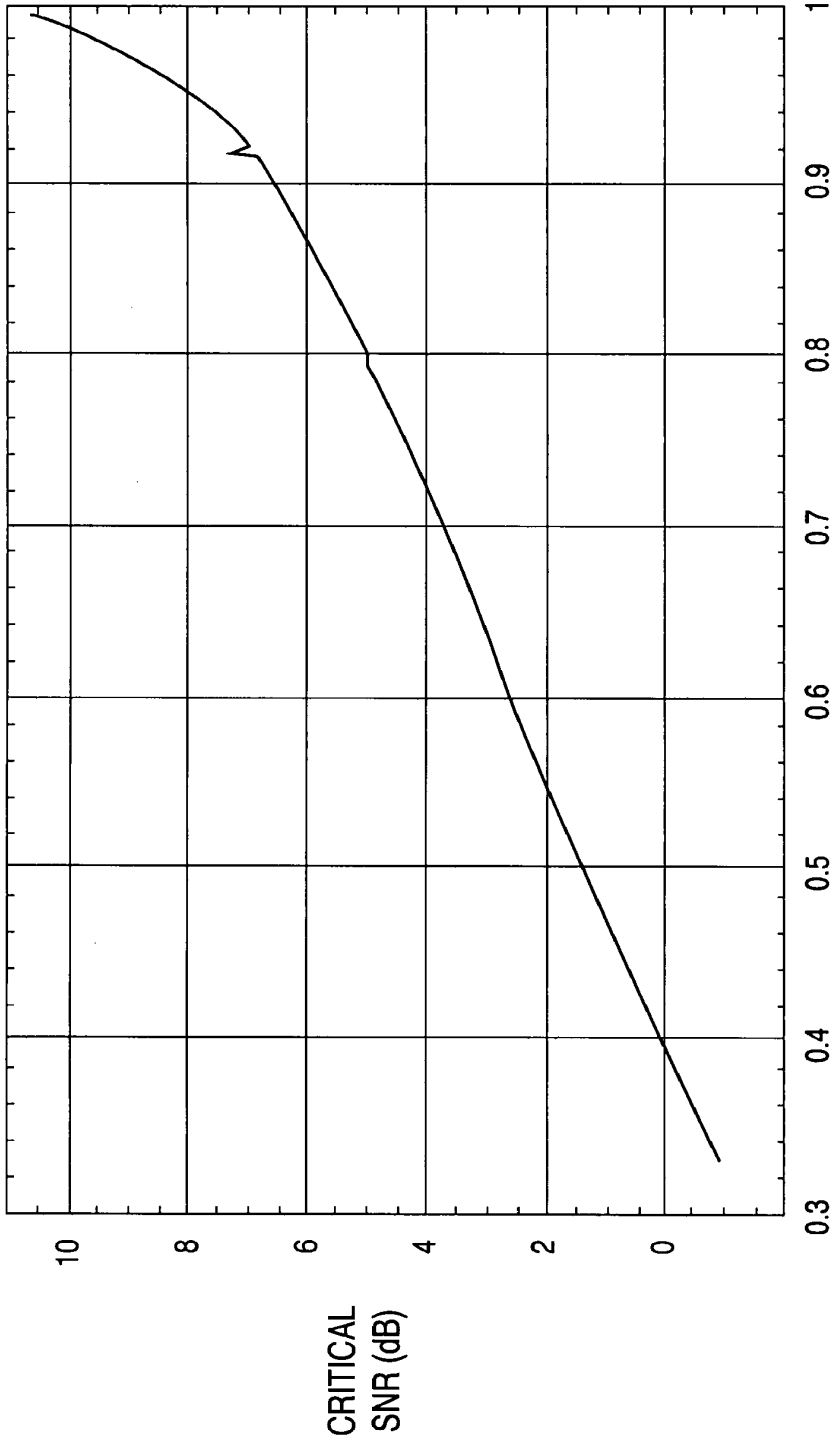


FIG. 8

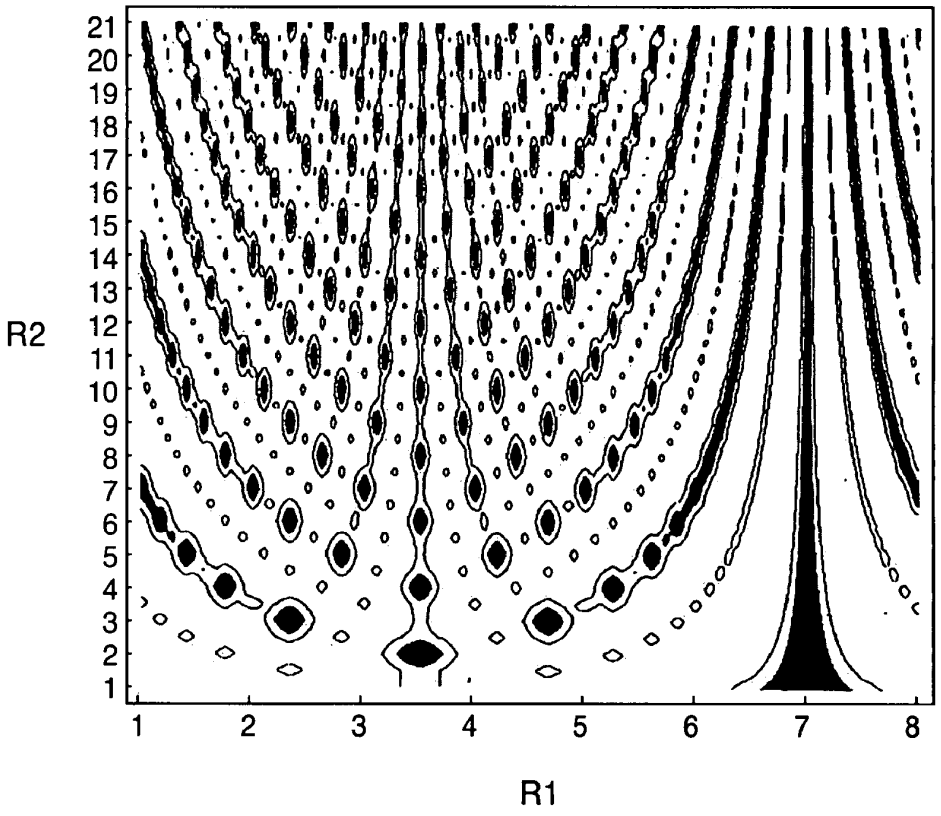


FIG. 9

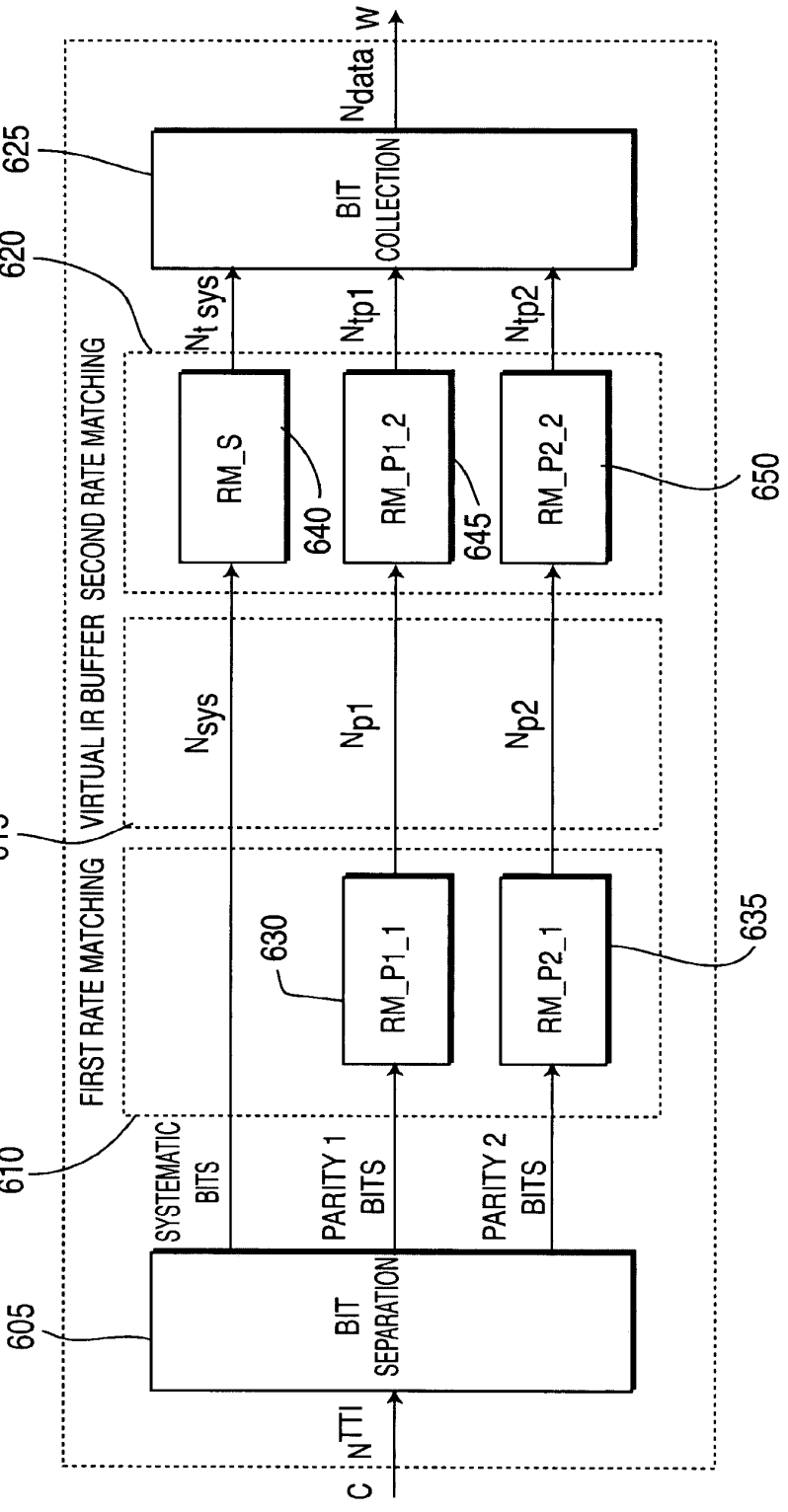

600
625
620
615
610
605
630
635
640
645
650
C
NTTI
BIT SEPARATION
SYSTEMATIC BITS
PARITY 1 BITS
PARITY 2 BITS
FIRST RATE MATCHING
VIRTUAL IR BUFFER
SECOND RATE MATCHING
RM_P1_1
RM_P2_1
RM_S
RM_P1_2
RM_P2_2
Nsys
Np1
Np2
Nt sys
Ntp1
Ntp2
BIT COLLECTION
Ndata
W

FIG. 10

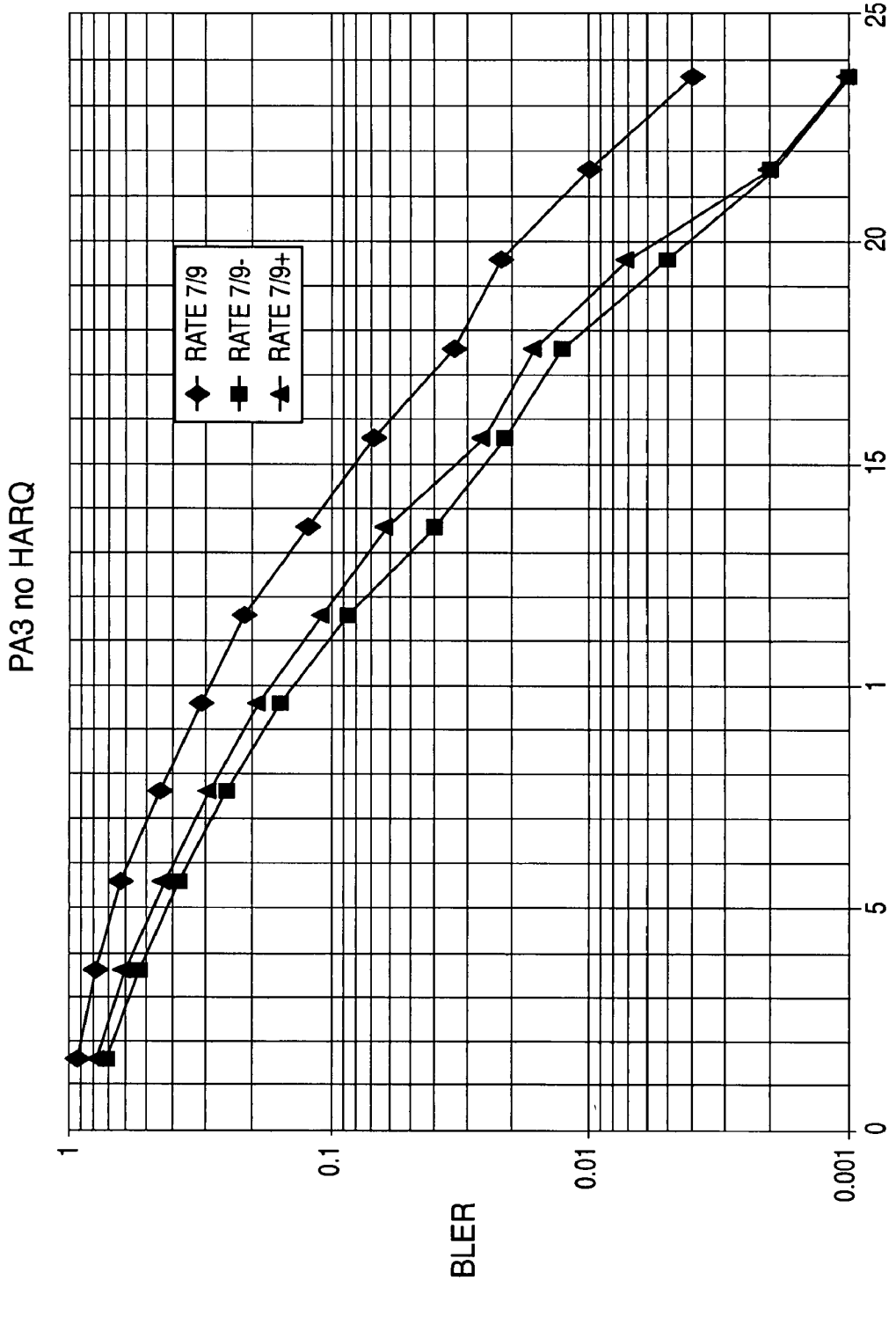

PA3 no HARQ
RATE 7/9
RATE 7/9-
RATE 7/9+
BLER
1
0.1
0.01
0.001
0
5
1
15
20
25
Ior/Ioc

FIG. 11

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
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Title of the Invention	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES		
Attorney Docket Number	I-2-0526US05	**Small Entity Status Claimed**	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		**Sub Class (if any)**	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	12	**Suggested Figure for Publication (if any)**	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	24374		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	13309962	2011-12-02

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

Prior Application Status	Patented			Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
13309962	Continuation of	11974381	2007-10-12	8074143	2011-12-06
Prior Application Status	Patented			Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
11974381	Continuation of	10725779	2003-12-02	7293217	2012-12-30
Prior Application Status	Patented			Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
10725779	non provisional of	60434232	2002-12-16	7293217	2007-11-06
Prior Application Status	Patented			Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
10725779	non provisional of	60444068	2003-01-30	7293217	2007-11-06
Prior Application Status	Patented			Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
10725779	non provisional of	60470921	2003-05-15	7293217	2007-11-06
Prior Application Status	Patented			Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
10725779	non provisional of	60494404	2003-08-11	7293217	2007-11-06

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Remove

Application Number	Country i	Filing Date (YYYY-MM-DD)	Priority Claimed
			◯ Yes ◯ No

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Authorization to Permit Access:

PTO/AIA/14 (08-12)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	I-2-0526US05
	Application Number	
Title of Invention	DETECTION, AVOIDANCE AND/OR CORRECTION OF PROBLEMATIC PUNCTURING PATTERNS IN PARITY BIT STREAMS USED WHEN IMPLEMENTING TURBO CODES	

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

○ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

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

Mailing Address Information:			
Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section only if non-applicant assignee information is desired to be included on the patent application publication in accordance with 37 CFR 1.215(b). Do not include in this section an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest), as the patent application publication will include the name of the applicant(s).

Remove

If the Assignee is an Organization check here. ☒

Organization Name	INTERDIGITAL TECHNOLOGY CORPORATION

Mailing Address Information:			
Address 1	200 Bellevue Parkway		
Address 2	Suite 300		
City	Wilmington	**State/Province**	DE
Country i		Postal Code	19809
Phone Number		Fax Number	
Email Address			

Additional Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications			
Signature	/Baha A. Obeidat/	Date (YYYY-MM-DD)	2013-01-18

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

First Name	Baha A.	Last Name	Obeidat	Registration Number	66827

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This collection of information is required by 37 CFR 1.76. 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 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet 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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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:

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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.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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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 inspections 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.

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
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:	Baha A. Obeidat/Patricia Petaccia
Attorney Docket Number:	I-2-0526US05

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility application filing	1011	1	390	390
Utility Search Fee	1111	1	620	620
Utility Examination Fee	1311	1	250	250
Pages:				
Claims:				
Miscellaneous-Filing:				
Late filing fee for oath or declaration	1051	1	130	130
Petition:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1390**

Electronic Acknowledgement Receipt	
EFS ID:	14736502
Application Number:	13744984
International Application Number:	
Confirmation Number:	9610
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:	Baha A. Obeidat/Patricia Petaccia
Filer Authorized By:	Baha A. Obeidat
Attorney Docket Number:	I-2-0526US05
Receipt Date:	18-JAN-2013
Filing Date:	
Time Stamp:	15:22:17
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1390
RAM confirmation Number	2123
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		I_2_0526US05_APPLN.PDF	2387291 4e60eb772dacdae51a8fbb9d5faecf6aad46b7bf	yes	46

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	41
Claims	42	45
Abstract	46	46

Warnings:

Information:

2	Drawings-only black and white line drawings	I_2_0526US05_Drawings.PDF	247238 a5cfeaa6a280db12caed55daeb0037967d47b2e2	no	12

Warnings:

Information:

3	Application Data Sheet	ADS_526US05.PDF	1916768 7663747fb8fa91f3633d2d7dc1c6c3ac6c397e69	no	7

Warnings:

Information:

4	Fee Worksheet (SB06)	fee-info.pdf	36885 02337cb862efc4cd0db0c39651ffa3aae5c90552	no	2

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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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