8585976

THE UNITED STATES OF AMERICA

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UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

March 27, 2025

THIS IS TO CERTIFY THAT ANNEXED IS A TRUE COPY FROM THE RECORDS OF THIS OFFICE OF THE FILE WRAPPER AND CONTENTS OF:

APPLICATION NUMBER: *16/552,927*
FILING DATE: *August 27, 2019*
PATENT NUMBER: *11032111*
ISSUE DATE: *June 08, 2021*

Certified by

ACTING DIRECTOR OF THE UNITED STATES PATENT AND TRADEMARK OFFICE

PTO/AIA/14 (02-18)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	20160.0031.NPUS00
	Application Number	
Title of Invention	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS	

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
	Junqing		SUN	

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

City	Fremont	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	c/o Credo Inc., 1600 Technology Drive, Fifth Floor
Address 2	

City	San Jose	State/Province	CA
Postal Code	95110	Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Haoli		QIAN	

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

City	Fremont	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	c/o Credo, Inc.
Address 2	1600 Technology Drive, Fifth Floor

City	San Jose	State/Province	CA
Postal Code	95110	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	20160.0031.NPUS00
	Application Number	
Title of Invention	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS	

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

Customer Number	63467		
Email Address	uspto@rameyfirm.com	Add Email	Remove Email

Application Information:

Title of the Invention	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS		
Attorney Docket Number	20160.0031.NPUS00	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	7	**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	63467		

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Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim 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" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Claims benefit of provisional	62723701	2018-08-28

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 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. 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(i)(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).

Remove

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

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

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.

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Title of Invention	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is 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 State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	20160.0031.NPUS00
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Title of Invention	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS	

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. ☒

Organization Name	CREDO TECHNOLOGY GROUP LIMITED		
Mailing Address Information For Applicant:			
Address 1	Ugland House		
Address 2			
City	Grand Cayman	**State/Province**	
Country	KY	Postal Code	KY1-1104
Phone Number		Fax Number	
Email Address			

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

Assignee Information including Non-Applicant Assignee 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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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.

Remove

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

Organization Name	CREDO TECHNOLOGY GROUP LIMITED

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1	Ugland House		
Address 2			
City	Grand Cayman	**State/Province**	
Country i	KY	Postal Code	KY1-1104
Phone Number		Fax Number	
Email Address			

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

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Daniel J. Krueger/			Date (YYYY-MM-DD)	2019-08-27
First Name	Daniel J.	Last Name	Krueger	Registration Number	42771

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

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	Application Number	
Title of Invention	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS	

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 CooperationTreaty.

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.

FIG. 1

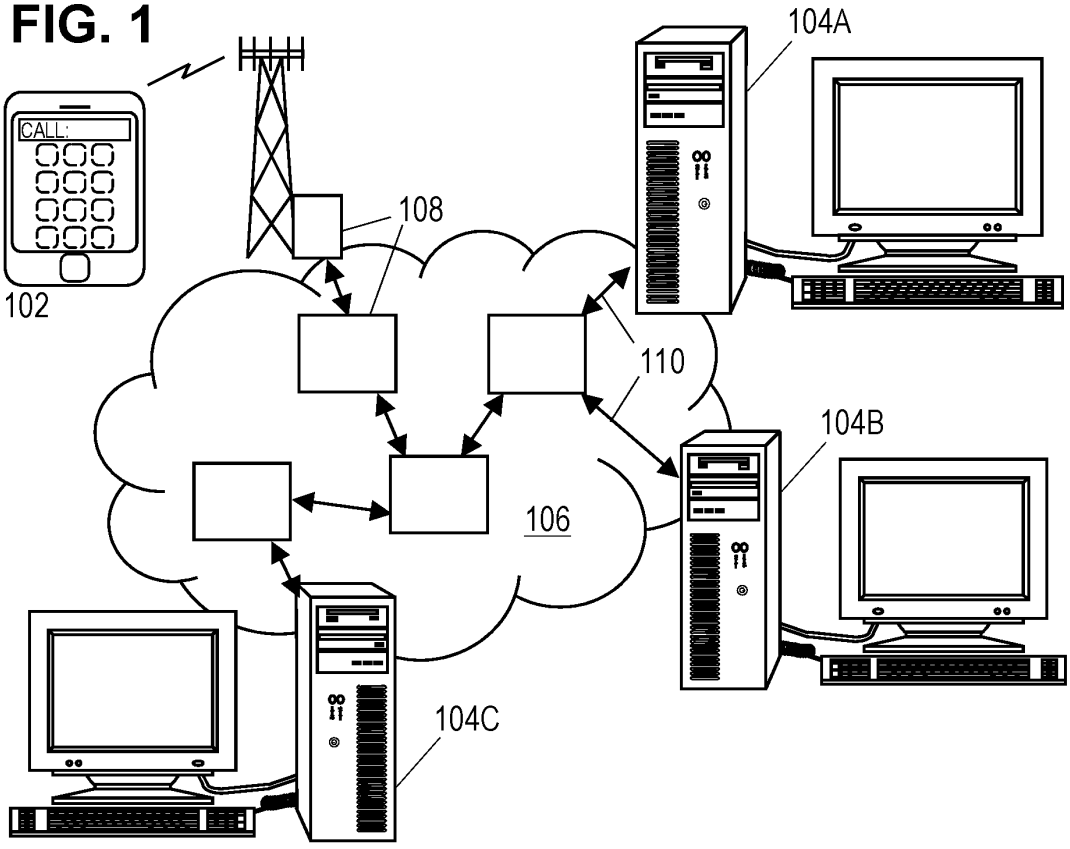


FIG. 2

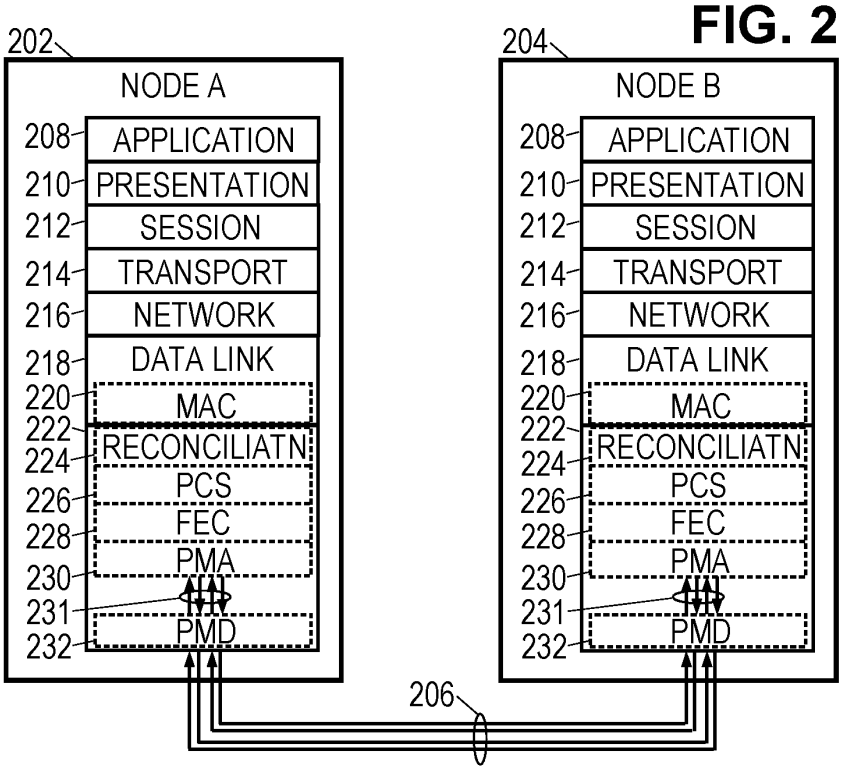

202
NODE A
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APPLICATION
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PRESENTATION
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SESSION
214
TRANSPORT
216
NETWORK
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DATA LINK
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MAC
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RECONCILIATN
224
PCS
226
FEC
228
PMA
230
231
PMD
232
204
NODE B
208
APPLICATION
210
PRESENTATION
212
SESSION
214
TRANSPORT
216
NETWORK
218
DATA LINK
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MAC
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PCS
226
FEC
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PMA
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231
PMD
232
206

FIG. 3

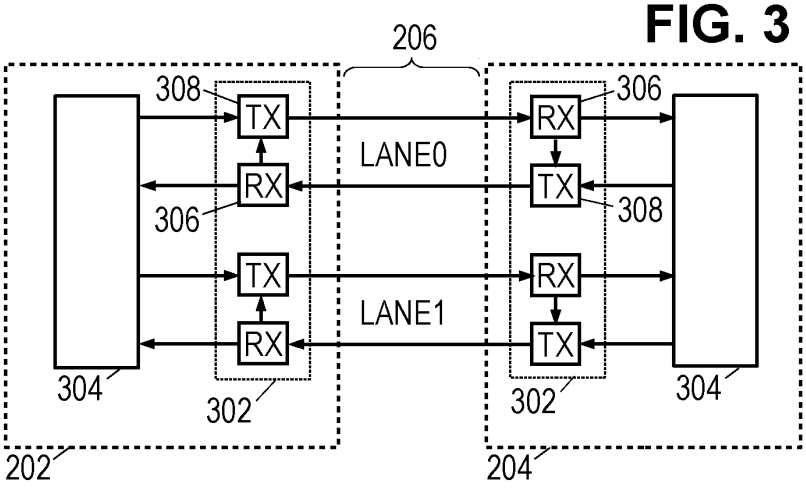
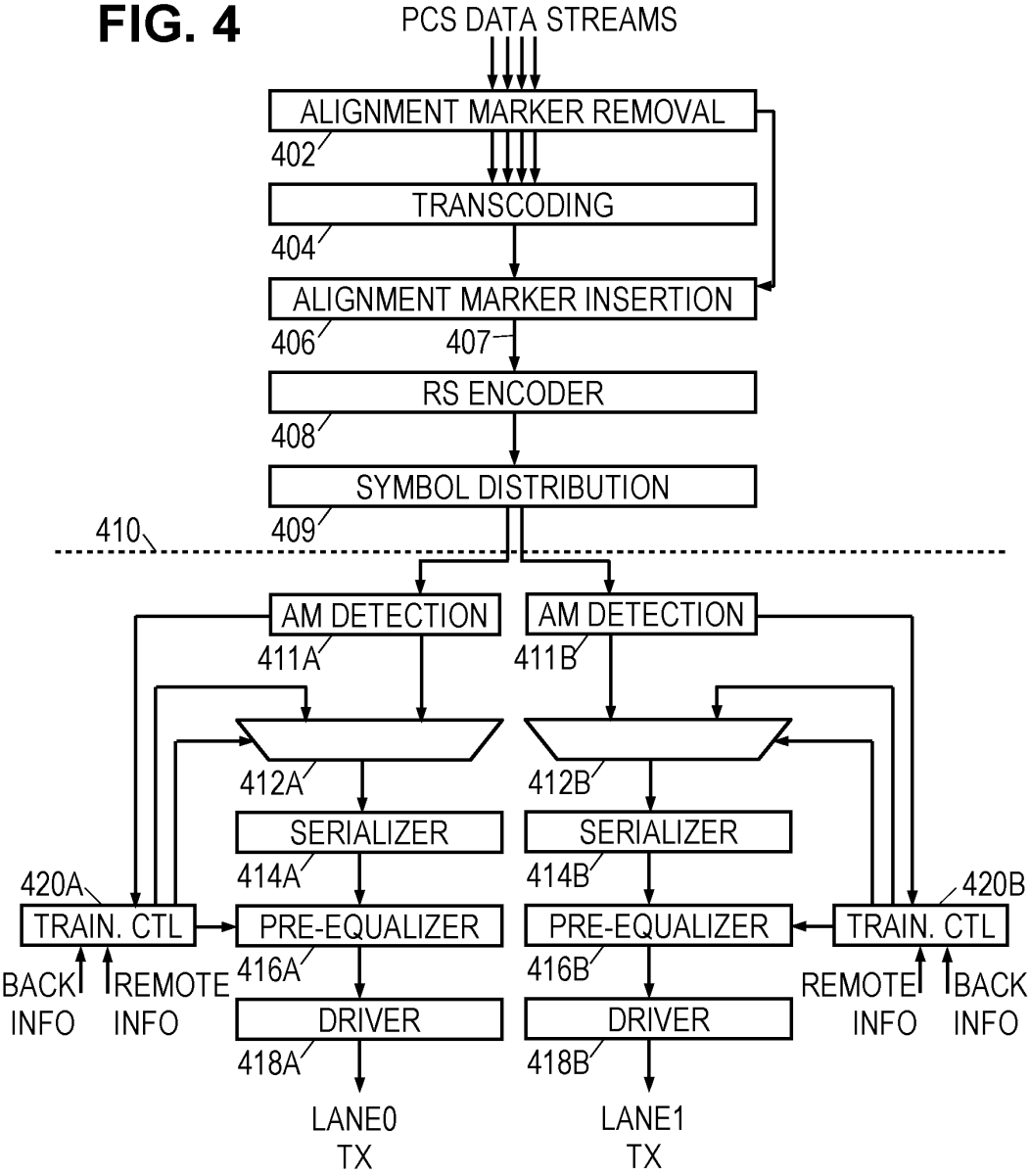

206
308
TX
RX
LANE0
306
RX
TX
306
308
TX
RX
LANE1
304
302
302
304
202
204

FIG. 4


PCS DATA STREAMS
ALIGNMENT MARKER REMOVAL
402
TRANSCODING
404
ALIGNMENT MARKER INSERTION
406
407
RS ENCODER
408
SYMBOL DISTRIBUTION
409
410
AM DETECTION
411A
AM DETECTION
411B
412A
412B
SERIALIZER
414A
SERIALIZER
414B
420A
TRAIN. CTL
PRE-EQUALIZER
416A
PRE-EQUALIZER
416B
TRAIN. CTL
420B
BACK INFO
REMOTE INFO
DRIVER
418A
DRIVER
418B
REMOTE INFO
BACK INFO
LANE0 TX
LANE1 TX

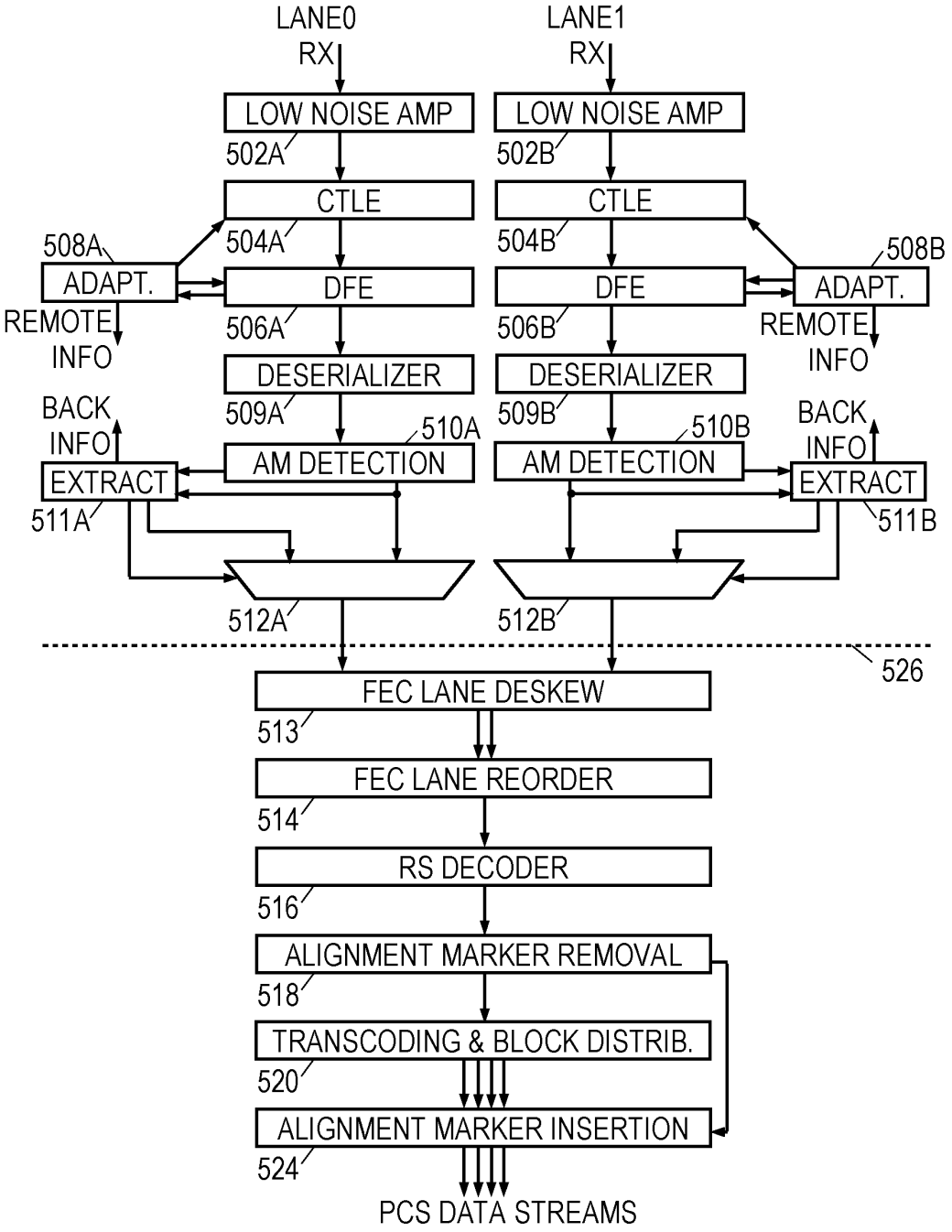

LANE0
RX
LANE1
RX
LOW NOISE AMP
502A
LOW NOISE AMP
502B
CTLE
504A
CTLE
504B
508A
ADAPT.
DFE
506A
DFE
506B
ADAPT.
508B
REMOTE INFO
REMOTE INFO
DESERIALIZER
509A
DESERIALIZER
509B
BACK INFO
510A
AM DETECTION
AM DETECTION
510B
BACK INFO
EXTRACT
511A
EXTRACT
511B
512A
512B
526
FEC LANE DESKEW
513
FEC LANE REORDER
514
RS DECODER
516
ALIGNMENT MARKER REMOVAL
518
TRANSCODING & BLOCK DISTRIB.
520
ALIGNMENT MARKER INSERTION
524
PCS DATA STREAMS

FIG. 5

FIG. 6A

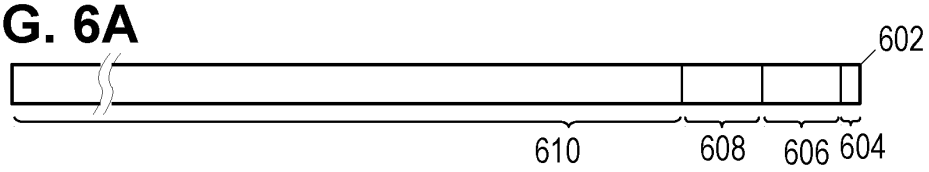


FIG. 6B

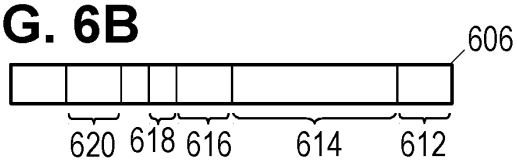


FIG. 6C

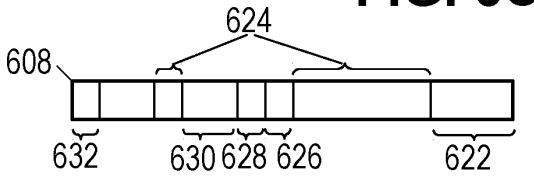


FIG. 7A

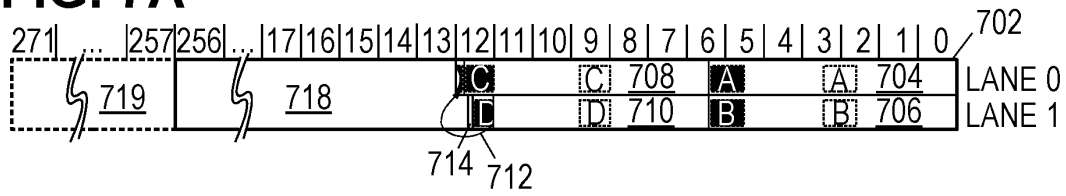


FIG. 7B

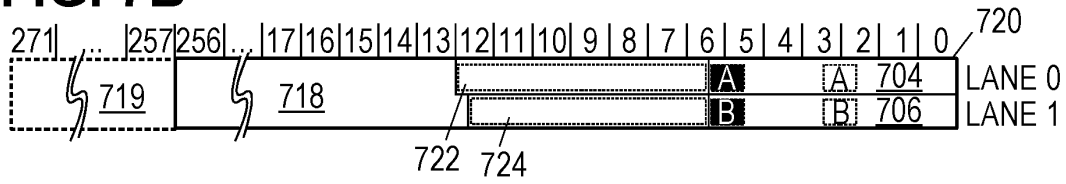


FIG. 7C

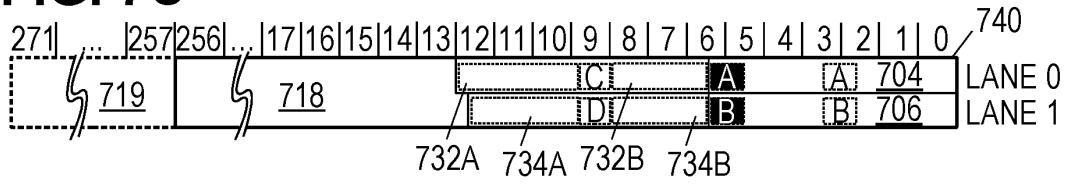


FIG. 7D

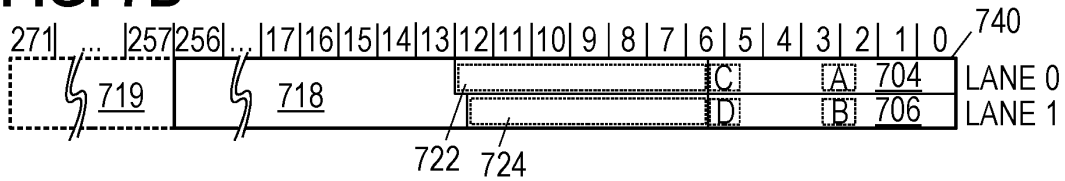


FIG. 8

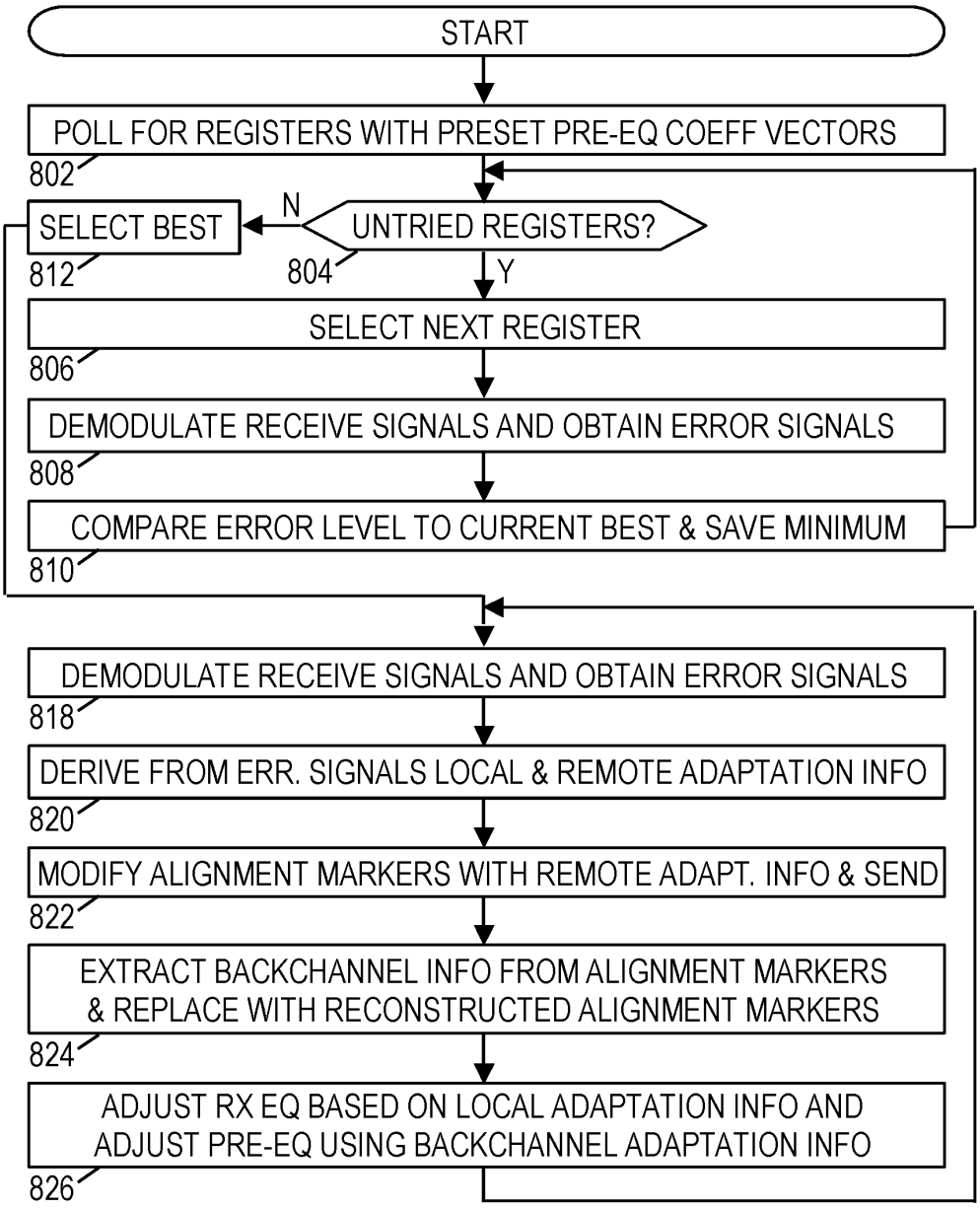
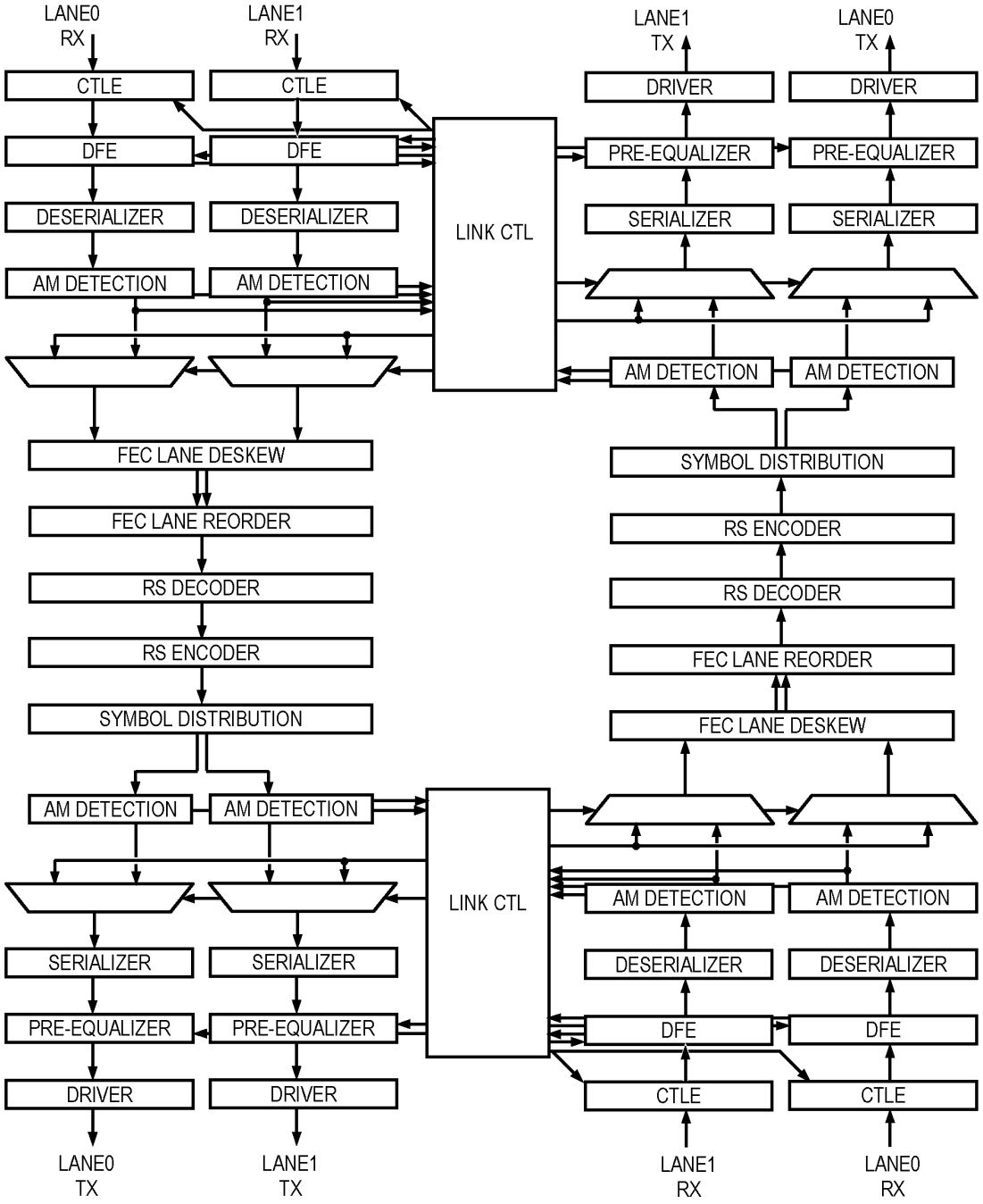

START
POLL FOR REGISTERS WITH PRESET PRE-EQ COEFF VECTORS
802
SELECT BEST
812
N
UNTRIED REGISTERS?
804
Y
SELECT NEXT REGISTER
806
DEMODULATE RECEIVE SIGNALS AND OBTAIN ERROR SIGNALS
808
COMPARE ERROR LEVEL TO CURRENT BEST & SAVE MINIMUM
810
DEMODULATE RECEIVE SIGNALS AND OBTAIN ERROR SIGNALS
818
DERIVE FROM ERR. SIGNALS LOCAL & REMOTE ADAPTATION INFO
820
MODIFY ALIGNMENT MARKERS WITH REMOTE ADAPT. INFO & SEND
822
EXTRACT BACKCHANNEL INFO FROM ALIGNMENT MARKERS & REPLACE WITH RECONSTRUCTED ALIGNMENT MARKERS
824
ADJUST RX EQ BASED ON LOCAL ADAPTATION INFO AND ADJUST PRE-EQ USING BACKCHANNEL ADAPTATION INFO
826

FIG. 9


LANE0 RX
LANE1 RX
LANE1 TX
LANE0 TX
CTLE
CTLE
DRIVER
DRIVER
DFE
DFE
PRE-EQUALIZER
PRE-EQUALIZER
DESERIALIZER
DESERIALIZER
SERIALIZER
SERIALIZER
LINK CTL
AM DETECTION
AM DETECTION
AM DETECTION
AM DETECTION
FEC LANE DESKEW
SYMBOL DISTRIBUTION
FEC LANE REORDER
RS ENCODER
RS DECODER
RS DECODER
RS ENCODER
FEC LANE REORDER
SYMBOL DISTRIBUTION
FEC LANE DESKEW
AM DETECTION
AM DETECTION
LINK CTL
AM DETECTION
AM DETECTION
SERIALIZER
SERIALIZER
DESERIALIZER
DESERIALIZER
PRE-EQUALIZER
PRE-EQUALIZER
DFE
DFE
DRIVER
DRIVER
CTLE
CTLE
LANE0 TX
LANE1 TX
LANE1 RX
LANE0 RX

SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Provisional Application US 62/723,701, filed 2018-08-28 and titled "SerDes Pre-Equalizer Having Efficient Adaptation" by inventors J.Sun and H.Qian, which is hereby incorporated herein by reference. This application further relates to Application US 15/654,446, filed 2017-07-19 and titled "SerDes Architecture with a Hidden Backchannel Protocol" by inventor J.Sun.

BACKGROUND

[0002] The Institute of Electrical and Electronics Engineers (IEEE) Standards Association publishes an IEEE Standard for Ethernet, IEEE Std 802.3-2015, which will be familiar to those of ordinary skill in the art to which this application pertains. This standard provides a common media access control specification for local area network (LAN) operations at selected speeds from 1 Mb/s to 100 Gb/s over coaxial cable, twisted wire pair cable, fiber optic cable, and electrical backplanes, with various channel signal constellations. As demand continues for ever-higher data rates, extensions to the standard must account for increased channel attenuation and dispersion even as the equalizers are forced to operate at faster symbol rates. One potential course of action employs enhanced equalization techniques, but such techniques should be implemented in a manner that does not limit performance or introduce undesirable hardware complexity or cost.

SUMMARY

[0003] Accordingly, there are disclosed herein a serializer-deserializer (SerDes) architecture and method that implements an efficient adaptation interface for transmitter pre-equalizers in a standards-suitable fashion. An illustrative SerDes (serializer-deserializer) communications method embodiment may include a transceiver: selecting one of multiple registers to specify initial pre-equalizer coefficient values; updating the initial pre-equalizer coefficient values during a training phase; and using the updated pre-equalizer coefficient values to convey a transmit data stream.

[0004] In an illustrative embodiment of a chip-to-module communications link, a port connector

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couples a port transceiver to a pluggable module transceiver, the pluggable module transceiver including: one or more transmit filters to each pre-equalize a corresponding serial symbol stream being transmitted to the port transceiver; and a controller having multiple registers, each of the multiple registers containing a set of initial coefficient values, the controller using one of the registers to set initial coefficient values for the one or more transmit filters.

[0005] Each of the foregoing embodiments may be implemented individually or in combination, and may be implemented with any one or more of the following features in any suitable combination: 1. each of the multiple registers corresponds to a different channel model. 2. at least some of the different channel models are for chip-to-module (C2M) channels with different insertion loss and package loss characteristics. 3. at least some of the different channel models presume different types of receiver equalization. 4. said selecting includes using the initial pre-equalizer coefficient values to determine a performance characteristic for each of the multiple registers. 5. the performance characteristic is an error signal energy. 6. the performance characteristic is a bit error rate. 7. updating the selected register with the updated pre-equalizer coefficient values. 8. one of the registers is selected by the port transceiver to specify the initial coefficient values. 9. the port transceiver iteratively selects different ones of the multiple registers and determines a performance characteristic for each. 10. the port transceiver generates updates for the coefficient values of the one or more transmit filters. 11. the controller saves updated coefficient values in one of the registers. 12. performing simultaneous updates of multiple coefficients values. 13. performing coarse updates before performing fine updates of coefficient values.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] In the drawings:

[0007] Fig. 1 shows an illustrative communications network.

[0008] Fig. 2 is a diagram of an illustrative multi-lane communications link model.

[0009] Fig. 3 is a block diagram of an illustrative communications link.

[0010] Fig. 4 is a block diagram of a transmit chain in an illustrative multi-lane transceiver.

[0011] Fig. 5 is a block diagram of a receive chain in an illustrative multi-lane transceiver.

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[0012] Figs. 6A-6C show fields of an illustrative training frame.

[0013] Fig. 7A shows sets of grouped alignment markers in an illustrative multi-lane data stream.

[0014] Fig. 7B shows a first data stream embodiment having hidden backchannel fields.

[0015] Fig. 7C shows a second data stream embodiment having hidden backchannel fields.

[0016] Fig. 7D shows a third data stream embodiment having hidden backchannel fields.

[0017] Fig. 8 is a flowchart of an illustrative multi-lane communications method.

[0018] Fig. 9 is a block diagram of an illustrative pluggable module.

[0019] It should be understood, however, that the specific embodiments given in the drawings and detailed description do not limit the disclosure. On the contrary, they provide the foundation for one of ordinary skill to discern the alternative forms, equivalents, and modifications that are encompassed in the scope of the appended claims.

DETAILED DESCRIPTION

[0020] The disclosed apparatus and methods are best understood in the context of the larger environments in which they operate. Accordingly, Fig. 1 shows an illustrative communications network 100 including mobile devices 102 and computer systems 104A-C coupled via a routing network 106. The routing network 106 may be or include, for example, the Internet, a wide area network, or a local area network. In Fig. 1, the routing network 106 includes a network of equipment items 108, such as switches, routers, and the like. The equipment items 108 are connected to one another, and to the computer systems 104A-C, via point-to-point communication links 110 that transport data between the various network components. At least some of the links 110 in network 106 are high-speed multi-lane links such as Ethernet links operating in compliance with the IEEE Std 802.3-2015 (or later) at 10 Gb/s or more.

[0021] Fig. 2 shows a communications link between two nodes 202, 204, that operate in accordance with the ISO/IEC Model for Open Systems Interconnection (See ISO/IEC 7498-1:1994.1) to communicate over a physical medium represented by transmit and receive channels 206. The interconnection reference model employs a hierarchy of layers with defined functions and interfaces to facilitate the design and implementation of compatible systems by different

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teams or vendors. While it is not a requirement, it is expected that the higher layers in the hierarchy will be implemented primarily by software or firmware operating on programmable processors while the lower layers may be implemented as application-specific hardware.

[0022] The Application Layer 208 is the uppermost layer in the model, and it represents the user applications or other software operating on different systems (e.g., equipment 108), which need a facility for communicating messages or data. The Presentation Layer 210 provides such applications with a set of application programming interfaces (APIs) that provide formal syntax, along with services for data transformations (e.g., compression), establishing communication sessions, connectionless communication mode, and negotiation to enable the application software to identify the available service options and select therefrom. The Session Layer 212 provides services for coordinating data exchange including: session synchronization, token management, full- or half-duplex mode implementation, and establishing, managing, and releasing a session connection. In connectionless mode, the Session Layer may merely map between session addresses and transport addresses.

[0023] The Transport Layer 214 provides services for multiplexing, end-to-end sequence control, error detection, segmenting, blocking, concatenation, flow control on individual connections (including suspend/resume), and implementing end-to-end service quality specifications. The focus of the Transport Layer 214 is end-to-end performance/behavior. The Network Layer 216 provides a routing service, determining the links used to make the end-to-end connection and when necessary acting as a relay service to couple together such links. The Data link layer 218 serves as the interface to physical connections, providing delimiting, synchronization, sequence and flow control across the physical connection. It may also detect and optionally correct errors that occur across the physical connection. The Physical layer 222 provides the mechanical, electrical, functional, and procedural means to activate, maintain, and deactivate channels 206, and to use the channels 206 for transmission of bits across the physical media.

[0024] The Data Link Layer 218 and Physical Layer 222 are subdivided and modified slightly by IEEE Std 802.3-2015, which provides a Media Access Control (MAC) Sublayer 220 in the Data Link Layer 218 to define the interface with the Physical Layer 222, including a frame structure and transfer syntax. Within the Physical Layer 222, the standard provides a variety of possible

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subdivisions such as the one illustrated in Fig. 2, which includes an optional Reconciliation Sublayer 224, a Physical Coding Sublayer (PCS) 226, a Forward Error Correction (FEC) Sublayer 228, a Physical Media Attachment (PMA) Sublayer 230, and a Physical Medium Dependent (PMD) Sublayer 232.

[0025] The optional Reconciliation Sublayer 224 merely maps between interfaces defined for the MAC Sublayer 220 and the PCS Sublayer 226. The PCS Sublayer 226 provides scrambling/descrambling, data encoding/decoding (with a transmission code that enables clock recovery and bit error detection), block and symbol redistribution, PCS alignment marker insertion/removal, and block-level lane synchronization and deskew. To enable bit error rate estimation by components of the Physical Layer 222, the PCS alignment markers typically include Bit-Interleaved-Parity (BIP) values derived from the preceding bits in the lane up to and including the preceding PCS alignment marker.

[0026] The FEC Sublayer 228 provides, e.g., Reed-Solomon coding/decoding that distributes data blocks with controlled redundancy across the lanes to enable error correction. In some embodiments (e.g., in accordance with Article 91 or proposed Article 134 for the IEEE Std 802.3), the FEC Sublayer 228 modifies the number of lanes. For example, under proposed Article 134, a four-lane outgoing data stream (including PCS alignment markers) may be converted into a two-lane transmit data stream. Conversely, the FEC Sublayer 228 may convert a two-lane receive data stream into a four-lane incoming data stream. In both directions, the PCS alignment markers may be preserved, yielding pairs (or more generally, "sets") of grouped PCS alignment markers in the multi-lane data streams being communicated to and from the PMA Sublayer 230. (Article 91 provides for a 20-to-4 lane conversion, yielding sets of 5 grouped PCS alignment markers in each lane of the data streams communicated between the FEC and PMA sublayers.)

[0027] The PMA Sublayer 230 provides lane remapping, symbol encoding/decoding, framing, and octet/symbol synchronization. In at least some contemplated embodiments, the multi-lane data stream 231 communicated to and from the PMA Sublayer 230 complies with the attachment unit interface (AUI) requirements of the IEEE standard. Several varieties of the AUI requirements exist and are named based on the nominal bit rate and the number of lanes. For example, Annexes 120E and 135G to the IEEE standard provide requirements for 50GAUI-1, 100GAUI-2,

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200GAUI-4, and 400GAUI-8, which respectively employ 1, 2, 4, and 8 lanes of NRZ signaling at a per-lane symbol rate of 53.125 GBd. Recently proposed extensions provide requirements for 100GAUI-1, 200GAUI-2, 400GAUI-4, and 800GAUI-8, which respectively employ 1, 2, 4, and 8 lanes of PAM4 signaling at per-lane symbol rates of 53.125 GBd.

[0028] The PMD Sublayer 232 specifies the transceiver conversions between transmitted/received channel signals and the corresponding AUI-compliant bit (or digital symbol) streams. The PMD Sublayer also implements an initial start-up of the communications channels 206, optionally conducting an auto-negotiation phase and a link-training phase before entering a normal operating phase. The auto-negotiation phase enables the end nodes to exchange information about their capabilities, and the training phase enables the end nodes to adapt both transmit-side and receive-side equalization filters in a fashion that combats the channel non-idealities

[0029] More information regarding the operation of the sublayers, as well as the electrical and physical specifications of the connections between the nodes and the communications medium (e.g., pin layouts, line impedances, signal voltages & timing), arrangements of the communications medium (e.g., the network topology), and the electrical and physical specifications for the communications medium itself (e.g., conductor arrangements in copper or fiber optic cable, limitations on attenuation, propagation delay, signal skew), can be found in the standard, and any such details should be considered to be well within the knowledge of those having ordinary skill in the art. The discussion below focuses on modifications specific to the present disclosure.

[0030] Fig. 3 provides a block diagram of those portions of nodes 202, 204, that may implement the Data Link Layer 218 and Physical Layer 222. Transceivers 302 for multiple transmit and receive channels are coupled to a host interface 304. The transceivers 302 and host interface 304 may be, e.g., part of a network interface peripheral coupled to the I/O bus of a personal computer, server, network switch, or other network-connected electronic system. The host interface 304 may implement the MAC Sublayer, optional Reconciliation Sublayer, and PCS Sublayer, and elements of the FEC, PMA, and PMD Sublayers, as application-specific integrated circuitry to enable high-rate processing and data transmission. The illustrated transceivers 302, preferably

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embodied as application-specific integrated circuitry for very high-rate serial data transmission and reception, include multiple pairs of a receiver 306 and transmitter 308, each pair coupled to two unidirectional channels (a receive channel and a transmit channel) to implement one lane of a multi-lane physical connection. The physical connection thus accepts from each node transmit channel signals representing a multi-lane transmit stream and conveys the signals to the other node, delivering them as receive channel signals representing a multi-lane receive data stream. The receive signals may be degraded due to the physical channel's introduction of noise, attenuation, and signal dispersion.

[0031] Note that while the following discussion glosses over the traces conveying AUI-compliant multi-lane stream 231 between the PMA Sublayer 230 and the PMD Sublayer 232, focusing instead on communication channels 206, the disclosed principles are also applicable to this so-called "chip-to-module" (C2M) link, which will receive more detailed consideration after the description of Figs. 4-5.

[0032] Figs. 4 and 5 provide a more detailed block diagram of illustrative transmit and receive chains in the sublayers below the PCS. The transmit chain in Fig. 4 accepts a four-lane data stream from the PCS. Pursuant to the standard, the PCS data stream is already encoded with a transmission code that provides DC balance and enables timing recovery. The PCS data stream lanes further include PCS alignment markers for synchronizing the lanes with each other. Once the data stream lanes are aligned, an alignment marker removal module 402 removes the alignment markers from each lane, passing them to a downstream alignment marker insertion module 406. A transcoding module 404 modifies the transmission code from a 64b/66b code to a 256b/257b code more appropriate for use with the Reed-Solomon encoder. By repeatedly transcoding four 66-bit blocks taken in parallel from the four incoming lanes into individual 257-bit blocks, the transcoding module may essentially convert the four lanes into a single lane data stream.

[0033] The previously-mentioned alignment marker insertion module 406 accepts the PCS alignment marker information from removal module 402 and the single-lane data stream from transcoding module 404. The insertion module 406 combines the alignment marker information from the four lanes in a manner discussed further below to form a set of grouped alignment

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markers in a 257-bit block and, accounting for the operation of the transcoding module 404, inserts the alignment block in a fashion that preserves its location relative to the other data in the data stream 407. As described further with respect to Figs. 7A-7C, the alignment block is designed to account for the operation of the encoder module 408 and symbol distribution modules 409 such that the alignment markers appear essentially intact and in order in the two-lane transmit data stream crossing boundary 410.

[0034] A Reed-Solomon (RS) encoder module 408 operates on 10-bit "symbol" blocks of the data stream 407 from the insertion module 406, adding redundancy to enable downstream correction of symbol errors. Typically, the encoder module 408 operates to preserve the original data stream content while appending so-called "parity" information, e.g., 30 parity symbol blocks appended to 514 data symbol blocks to form a complete code word block. Thus the alignment blocks inserted by module 406 will remain present in the output data-stream from the encoder module. A symbol distribution module 409 distributes code word symbols across multiple transmission lanes in round-robin fashion, directing each lane to a corresponding transmitter. Boundary 410 may be considered as the boundary between the FEC sublayer 228 and the PMA sublayer 230. Where it is desired to maintain this boundary as strongly as possible, the PMA sublayer may include an alignment marker detection module 411A (and 411B) for each lane of the transmit data stream to detect the alignment markers inserted by module 406 with suitable data buffering. Alternatively, this boundary can be relaxed and the alignment marker detection modules 411A, 411B omitted in favor of appropriate direct signaling from the alignment marker insertion module 406. In either case, the training control modules 420A, 420B control the multiplexers 412A, 412B in each lane, based at least in part on detection signals indicating the presence of the alignment markers.

[0035] Multiplexers 412A, 412B forward the encoded data streams to serializer modules 414A, 414B during normal operations and in the absence of alignment markers. During auto-negotiation and training phases, the multiplexers supply negotiation and training data streams from the training control modules 420A, 420B to the serializers. During normal operations in the presence of alignment markers, the multiplexers 412A, 412B (acting as alignment marker replacement modules) supply the serializer modules with modified alignment markers as

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discussed further below. The serializers 414A, 414B, each accept a stream of transmit data blocks and convert the stream of blocks into a (higher-rate) stream of channel symbols. Where, for example, a 4-PAM signal constellation is used, each serializer may produce a stream of two-bit symbols.

[0036] Each stream of channel symbols is filtered by a pre-equalizer module 416A, 416B to produce a transmit signal, which is amplified and supplied to the transmit channel by a driver 418A, 418B. The pre-equalizer modules compensate for at least some of the channel dispersion, reducing or eliminating the need for receiver-side equalization. Such pre-equalization may be advantageous in that it avoids the noise enhancement often associated with receiver-side equalization and enables digital filtering with a reduced bit-width. The bit width reduction directly reduces power consumption by requiring a less complex filter, but may further reduce power consumption by obviating the parallelization that a more complex filter might require to operate at the required bandwidth. However, pre-equalization generally requires knowledge of the channel.

[0037] One or more training controllers 420A, 420B, operate to characterize the channel after conducting an initial auto-negotiation phase. During the auto-negotiation phase, at least one training controller generates a sequence of auto-negotiation frames conveying capabilities of the local node to the remote node and negotiating to select a combination of features to be used for subsequent communications. When the auto-negotiation phase is complete, each training controller generates a sequence of training frames, so that training is carried out independently on each of the lanes.

[0038] An illustrative training frame 602 is now described with reference to Figs. 6A-6C. The training frame 602 begins with a frame marker 604 indicating the start of the training frame. The frame marker 604 is followed by a coefficient update field 606, a status report field 608, and a training pattern 610. Unlike the training pattern, which provides a spectrally-dense channel symbol sequence to facilitate training, the preceding fields are sent using differential Manchester encoding to facilitate timing recovery and ensure reliable communication even with untrained equalizers.

[0039] Fig. 6B shows an illustrative coefficient update field 606, having a two-bit request field

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612 to indicate whether a selected coefficient should be incremented, decremented, maintained at the present value, or disabled; a six-bit selection field 614 to select one of up to 64 pre-equalizer coefficients; a two-bit modulation field 616 to select a desired modulation scheme (e.g., 2-PAM, 4-PAM, with or without precoding); a one-bit filter length field 618 to indicate whether the pre-equalization filter should be short (no more than four coefficients) or long (more than four coefficients); and a two-bit initialization request field 620 to select a pre-programmed set of pre-equalization coefficient values. The unlabeled fields may be reserved for future use. The training controller(s) may use the coefficient update field 606 to convey backchannel information, i.e., adjustments to the pre-equalization filter coefficients of the remote transmitter.

[0040] Fig. 6C shows an illustrative status report field 608, having a three-bit coefficient status field 622 to report a successful update to a coefficient, an unsuccessful update, or an error condition (e.g., coefficient not supported, maximum voltage or coefficient limit reached); a one-bit and five-bit (totaling six bit) coefficient selection echo field 624 to echo back the coefficient selection from the remote node; a one bit initial condition status field 626 to report successful or unsuccessful setting of the coefficient values to an initial set of preprogrammed values; a one-bit lock status field 628 to indicate whether the receiver has achieved frame lock; a modulation status field 630 to report which modulation scheme is being employed by the transmitter; and a one-bit receiver ready field 632 to indicate whether the local node has finished training and is ready to begin data transmission. The training controller(s) may use the status report field 608 to convey confirmations and other local status information to the remote node.

[0041] Returning to Fig. 4, the one or more training controllers 420A, B, receive backchannel information extracted by the receiver from the received data stream and use the backchannel information to adjust the coefficients of the pre-equalization filters. The controllers further receive "remote info", which includes locally-generated information for adapting the coefficients of the pre-equalization filter in the remote node. Based on this information the controllers populate the coefficient selection field 614 and request field 612 of the training frames to provide backchannel information to the remote node. As training frames are employed only during the training phase, and as it may be desirable to continue updating the pre-equalization filter during normal operations, the training controller(s) 420 may include similar backchannel information in

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or with the modified alignment markers supplied via multiplexers 412A, 412B during normal operations.

[0042] Though shown as a single lane, the 10-bit symbol blocks of data stream 407 can conceptually be arranged into two lanes in anticipation of the operation of symbol distribution module 409, which places adjacent symbol blocks in alternate lanes. Fig. 7A shows a 514 symbol message word 702 (corresponding to the length of twenty 257-bit blocks from transcoding module 404) in this fashion, with broken outline for the 30 parity symbols 719 to be appended by the Reed-Solomon encoder 408 to form a complete 544 symbol code word. The spacing of the alignment markers in the four-lane PCS data stream is such that when a set of grouped alignment markers are inserted in the data stream 407, the grouped alignment markers form the first 257 bits of a message word 702 (and also the first 257 bits of the resulting Reed-Solomon codeword) while data blocks 718 occupy the remainder of the message word. Within these 257 bits, the information from the four PCS data stream alignment markers are arranged in alternating 10-bit symbol blocks so that within each lane the information appears, in order, and as essentially intact PCS alignment markers 704, 706, 708, and 710. As the four 64-bit alignment markers fall one bit short of the 257-bit length of blocks put out by the transcoding module, a one-bit pad 714 is appended to the grouped alignment markers. Moreover, within these first 257 bits of the message word 702, the alignment markers don't align well with the 10-bit symbol block boundaries. To fill out a full 10-bit symbol in lane 0, a 2-bit portion of marker 710 is excerpted from position 712.

[0043] The alignment markers in the four lane PCS data stream carry bit-interleaved parity values (A, B, C, D in inverted and non-inverted versions) and employ unique marker (UM) patterns that are lane specific. The alignment insertion module 406 modifies the pattern of alignment marker 706 to agree with that of alignment marker 704, so that they share a common marker (CM) pattern to facilitate detection and synchronization of the two lanes at the receiver. The BIP values are preserved. While alignment makers 708, 710 could in theory be used to make the synchronization process more robust, their presence is only necessary for identifying lanes at the beginning of the communications process and thereafter only to convey the contents of their BIP fields. Once the lanes have been identified, the lane-specific patterns for markers 708, 710 are

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redundant and these patterns may be omitted to make room for backchannel information. Thus multiplexers 412A, 412B, optionally with the support of alignment marker detection modules 411A, 411B, may replace the sets of grouped alignment markers with modified versions as shown in Figs. 7B-7D.

[0044] In some embodiments, the replacements begin only after a "settling period" (e.g., for one second after the multi-lane communications begin) or after a predetermined number (e.g., 100) of grouped alignment markers have been sent, with all sets of grouped alignment markers being modified thereafter. In other embodiments, the replacements occur periodically, with 1 out of every 2 sets being replaced, or 2 out of 3, or (N-1) out of N, with N potentially ranging as high as 10^5 to provide at least one unmodified set on the order of once per second. In still other embodiments, the replacement may occur on an as-needed basis, e.g., when degradation or drift is observed in the performance of the equalizers. In these as-needed embodiments, the replacements may begin upon detection of the reduced performance and continue until training convergence is achieved.

[0045] In Fig. 7B the UM alignment markers 708 and 710 are replaced in their entireties by a backchannel adaptation field 722 having 66 bits and a backchannel status field 724 having 63 bits (including the former pad bit 714). At the receiver, the backchannel information is extracted and the alignment markers 708, 710 restored with placeholders for the lost BIP (inverted and non-inverted) values. With SerDes systems employing forward error correction, the BIP values are no longer essential for determining bit error rates, and in this implementation the BIP values are sacrificed for additional backchannel bandwidth that will not substantively impact the operation or throughput of the higher sublayers and layers.

[0046] Nevertheless, different implementations may be employed to prevent the loss of BIP values in the restored alignment markers. In Fig. 7C, the UM patterns and inverted BIP values are dropped from alignment markers 708, 710 while the non-inverted BIP values are left in place. The UM patterns and inverted BIP values are replaced by an adaptation field 732A, 732B (for marker 708) and a status field 734A, 734B. This approach preserves alignment markers 704 and 706 unchanged from the markers inserted by module 406 while reallocating 56 bits from each of markers 708, 710 for hidden backchannel fields 732, 734. At the receiver, the backchannel

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information is extracted and the alignment markers 708, 710 restored (and the BIP values preserved) without impact on the operation or throughput of the higher sublayers and layers.

[0047] In Fig. 7D, alignment markers 704, 706 are modified to replace their inverted BIP values with the non-inverted BIP values from alignment markers 708, 710. Their CM patterns remain unaffected so that the standard synchronization process still functions. Meanwhile, additional space is made available for backchannel information. As in Fig. 7B, backchannel adaptation field 722 has 66 bits while backchannel status field 724 has 63 bits (including the former pad bit 714). At the receiver, the backchannel information is extracted and the alignment markers 704, 706, 708, 710 are fully restored (and the BIP values preserved) without impact on the operation or throughput of the higher sublayers and layers.

[0048] As with the training frame, the backchannel information field(s) of the modified alignment markers may provide a six-bit field for selecting pre-equalization filter coefficients; a two-bit field for specifying that the selected coefficient should be incremented, decremented, maintained, or disabled; and perhaps a one-bit field for indicating whether the backchannel information field contains a valid command or should be ignored. The backchannel information field(s) may further provide a status report, with a six-bit field for echoing a filter coefficient selection; a two-bit field for indicating whether the coefficient has been updated, not updated, is at its limit, or is not supported; and perhaps a one-bit field for indicating that the receiver has obtained a lock on the lane alignments.

[0049] In an alternative embodiment, each coefficient of the pre-equalization filter may have a bit pair allocated within the modified alignment markers to indicate (in the adaptation field) whether that coefficient should be incremented, decremented, maintained, or disabled; or (in the status field) to indicate whether that coefficient is maximized, minimized, updated, or not updated.

[0050] As with the training frame, the backchannel information fields of the modified alignment markers may be encoded using differential Manchester encoding to ensure reliable delivery. Additionally or alternatively, reliability of the backchannel information field delivery may be enhanced using other techniques. For example, the backchannel information field may be sent redundantly, using multiple copies of a field to enable error detection and (for three or more

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copies) voting-based error correction. (Notably, a standards-compliant alignment marker includes a bitwise-inverted duplication of each element, which can be extended to include the backchannel information field. If an odd number of copies is desired, the last field may be partly inverted.) A parity check or short FEC code may also provide controlled redundancy enabling the detection and possible correction of bit errors.

[0051] Having discussed the transmit chain and the fields (including hidden fields 722-724 or 732-734) potentially employed to communicate backchannel information during the training and normal operations phases, we turn now to the operation of an illustrative receive chain such as that shown in Fig. 5. The receive chain obtains analog electrical signals from different receive channels (indicated by Lane0-rx and Lane1-rx). These may be obtained directly from electrical conductors, if the physical medium is an electrical bus or cable, or indirectly via transducers if the physical medium is wireless. Low noise amplifiers (LNA) 502A,B, each provide a high input impedance to minimize channel loading and amplifies the receive signal to drive the input of a continuous time linear equalizer (CTLE) filter 504A,B.

[0052] CTLE filters 504A,B provide continuous time filtering to shape the receive signal spectrum in an adaptive fashion to reduce the length of the channel impulse response while minimizing leading inter-symbol interference (ISI). Decision feedback equalizers (DFE) 506A,B operate on the filtered signals to correct for trailing ISI and detect each transmitted channel bit or symbol, thereby producing a demodulated digital data stream. Some embodiments employ oversampling. Clock recovery and adaptation modules 508A,B derive a sampling clock signal from the input and/or output of the DFE's decision element and supply it back to the DFE to control timing of the symbol detection. The adaptation modules 508A,B further derive an error signal of the DFE decision element's input relative to the output or (during the training phase) to a known training pattern, and use the error signal to adapt the DFE coefficient(s) and the response of the CTLE filters. The adaptation modules still further use the error signal to generate "remote info", i.e., adaptation information for the remote pre-equalizers. This remote info is supplied to the training controller(s) 420 (Fig. 4).

[0053] Deserializers 509A,B group the digital receive data stream bits or symbols into blocks to enable the use of lower clock rates for subsequent on-chip operations. Alignment marker

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detection modules 510A, 510B monitor the receive data stream to detect the CM pattern of the alignment markers and achieve alignment marker lock during normal operations, or during training operations to detect the training frame markers and achieve lock thereto. The backchannel information extraction modules 511A, 511B extract the backchannel information from the appropriate portions of the training frames and alignment markers, providing the pre-equalizer adaptation information and status report information to the training controller(s) 420. During normal operations, the multiplexers 512A, 512B, operating under control of the extraction modules 511A, 511B, replace the modified alignment markers with sets of grouped PCS alignment markers, thereby hiding the backchannel information fields from the higher layers. As with the transmit chain, the receive chain may impose a hard boundary 526 between the PMA sublayer and the FEC sublayer, or alternatively, the alignment marker detection information may be communicated to the FEC lane deskew module 513.

[0054] During normal operations, the receive data streams from the deserializers are aligned by an FEC lane deskew module 513. If the FEC lanes have somehow gotten switched, an FEC lane reordering module 514 detects the switch based on the contents of the alignment markers and compensates for the switch as the two lanes are multiplexed on a symbol-block basis into a single lane. An RS decoder module 516 operates on the single lane data stream to detect and correct any symbol errors, removing the FEC coding redundancy (parity symbols) during the decoding process.

[0055] A transcoding module 520 converts the 256b/257b transmission code words into blocks of four 64b/66b transmission code words distributing the 66-bit code word blocks across four PCS lanes. An alignment marker insertion module 524 converts the sets of grouped alignment markers into individual alignment markers having lane-specific UM patterns, and inserts the individual alignment markers at appropriate positions in the four lanes, accounting for the operation of the transcoding module 520. The four lane PCS data stream is provided to the higher hierarchy layers of the node for eventual communication of the conveyed data to the destination application.

[0056] With a sufficiently long pre-equalization filter, the DFE feedback filter may be kept quite short, at say 1 or 2 taps, and even when the channel has a relatively lengthy channel response,

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the pre-equalization filter may obviate any need for a digital feed forward equalizer (FFE) filter. In this case, the power savings associated with this architecture is expected to be substantial. With temperature changes and general evolution of the channel, however, ongoing adaptation of the pre-equalization filter (i.e., during the normal operations phase) is expected to be necessary.

[0057] Returning now to the C2M link, the PMD Sublayer 232 may often be implemented in the form of a pluggable module (e.g., a small form-factor pluggable (SFP) or one of its many variations including SFP+, cSFP, SFP-DD, QSFP, QSPF+, QSFP14, QSFP28, QSFP56, etc.) that is inserted into a port in a host such as a switch or a router. The pluggable module may be essentially a concatenation of the PMA Sublayer and transceiver components set forth in Figs. 4-5 to support bi-directional communications between the AUI lanes and the communication channels with or without the accompanying FEC encoding/decoding elements, as shown in Fig. 9. (The "Link Ctl" elements are each an aggregation of blocks 420, 508, and 511.) The stream 231 being communicated between the PMA and PMD sublayers may be transmitted from a packaged integrated circuit mounted to a printed circuit board (PCB) in the host, through traces on the PCB, through a "mated connector" (i.e., a receptacle with plug inserted to provide electrical contact between respective pins), through a capacitance, through traces on the PCB in the module, to a packaged integrated circuit mounted to the PCB module. The stream also includes signals traveling the opposite direction. At the contemplated signaling rates (26.5625 GBd or 53.125 GBd), the C2M link model includes up to 20 dB of signal attenuation (up to 4dB host package, up to 11.5dB host side trace, about 2.5 db module side trace, and about 2 dB module package).

[0058] The pluggable module should be usable with the widest possible range of host ports. Even though each port may be advertised as being compliant with the standard, different host manufacturers may employ different integrated circuit packages and different PCB layouts to connect the packaged ICs to the ports, causing the equivalent C2M link model to vary significantly between manufacturers or even between different products of a given manufacturer. To a limited extent, the host transceivers could be equipped with transmit-side and receive-side equalization that at least partly compensates for such variation; however there are severe limitations on the area, complexity, and power available on the host side of the link. A better

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option is to provide the pluggable module with flexibility to adapt to the different C2M link characteristics.

[0059] Accordingly, the manufacturer of the pluggable module may formulate a range of C2M link models using different assumptions based on known or predicted layouts and link characteristics, including "reference" transceivers. For example, the host-side receivers might be presumed to employ a continuous time linear equalizer (CTLE) in combination with any one of: (a) a four-tap DFE with a maximum first post-cursor tap coefficient of 0.5; (b) a four-tap DFE with a maximum first post-cursor tap coefficient of 0.2; (c) a four-tap DFE with a maximum first post-cursor tap coefficient of 0.0; (d) a five-tap linear equalizer with a one-tap DFE; (e) a five-tap linear equalizer with no DFE. These receiver assumptions, combined with different host-side trace lengths and package losses, may give rise to a reasonable number of potential C2M link models categories.

[0060] With the foregoing context, we now turn to certain variations offering more efficient training and adaptation of the pre-equalization implemented by the transmitter-side feed forward equalizer (FFE), suitable for a standard interface. As an initial matter, we may specify a maximum number of FFE coefficients for the pre-equalizer, e.g., 64 coefficients. We may further specify a minimum range for each coefficient and a minimum resolution such as, e.g., 1/64 or 1/128 of full swing. The drivers 418 (Fig. 4) operate as digital to analog converters, which we may require to provide a minimum equivalent number of bits (ENOB), e.g., 5 bits. The resulting combinatorial range of potential FFE coefficient values may be impractically large for a naïve training approach.

[0061] However, there are certain constraints, such as the reasonable number of C2M link model categories, that may be taken into account to improve the efficiency of the training and adaptation process. For the communication channels, we may require the channels to satisfy certain minimum qualification thresholds for, e.g., copper wire cabling or printed circuit board traces, which can be modeled. These models enable the design of "default" pre-equalizer coefficients for each case, e.g., minimum-quality channels, typical quality channels, and predictable variations thereof. The models, or at least the minimum qualification thresholds, may be chosen to require that the bulk of the pre-equalizer coefficient energy be concentrated at

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three or four major taps near the cursor (i.e., the FFE tap with nominally zero delay). The remainder of the coefficient taps may then be employed for reflection ("echo") reduction.

[0062] As another constraint, the transmitter FFE is expected to be limited in terms of power and/or maximum permitted voltage swing, such that the sum total of the coefficient values (including the sum of their absolute values) can be no greater than a predetermined limit. Once the limit is reached, the increase in magnitude of one coefficient value may need to be offset by the reduction in magnitude of at least one other coefficient value.

[0063] With the foregoing constraints, the "reasonable number" of channel model categories may be on the order of 16 or 32. Accordingly, we may provide a set of, e.g., 16 or 32 registers for the training controllers 420 (Fig. 4) or link controllers (Fig. 9) to store default coefficient values. A first register may store a vector of coefficient values suitable for a first channel response (e.g., a minimum-quality channel); a second register may store a vector of coefficient values suitable for a second channel response (e.g., a near-minimum quality channel with reduced dispersion); and so on. In some contemplated embodiments, the default coefficient values for each register, or at least some of the registers, would be set by the standard based on different channel loss profiles, while others of the registers may be reserved for configuration by customers of the original equipment manufacturer (OEM). In any case, at least some of the default coefficient values are preferably capable of being overwritten by the system controller or as part of the operating protocol to remember previous solutions and provide faster start-ups or failure recoveries. As part of the negotiating phase or training process, the coefficient values in each register may be communicated between the transmitter and receiver.

[0064] As previously mentioned, the channel qualification requirements are expected to enable pre-equalizer coefficient energy to be concentrated at the first three to four FFE taps, and thus in at least some contemplated embodiments the default coefficient values specified by the standard may be potentially nonzero for only the first four taps and may be zero for all higher taps. (In embodiments permitting the default coefficient values to be overwritten, this constraint may be omitted at least with respect to the replacement values.) To allow for fine-tuning of the default coefficient values, the standard may constrain the sum of the absolute value of the default coefficients to no more than certain percentage, e.g. 80%, of the predetermined limit for

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pre-equalizer. At least one of the default coefficient value registers is expected to provide a good starting point for training/adaptation, i.e., by providing an open decision eye at the input to the decision element if the receiver design is close to the reference receiver provided by the standard. With this starting point, the percentage constraint leaves room for convex optimization via known filter adaptation procedures such as, e.g., least mean squares (LMS) adaptation, or recursive least squares (RLS) adaptation. (The coefficient adaptations can be conveyed via the backchannel or via the management interface as discussed previously.) The reserved percentage (e.g., 20%) can thus be used to cancel reflections or increase signal swing as provided by the adaptation procedure.

[0065] Preferably, the predetermined limit on the sum of coefficient values is enforced (at least for the default coefficient values) by either the transmitter's training controller, or by the adaptation procedure which may be implemented at the receiver. If the limit is exceeded, the coefficient values for at least the major FFE taps, which may alternatively characterized as the first four taps or the largest coefficient magnitudes (though these are not necessarily the same), may be proportionally reduced to make room for further optimization.

[0066] Thus the pre-equalizer training/adaption process may proceed in stages. In a first stage, the default coefficient values are determined and stored in a set of registers. The default values may be set by the standard, and overwriting of the values by manufacturers, by system vendors, or alternatively by system controllers in the course of normal operations, may be permitted. In a second stage, the default coefficient values are communicated between the transmitter to the receiver, e.g., as the result of a register scan requested by the receiver during the auto-negotiation and/or training process when the channel is enabled or is recovering from failure. The receiver may select the starting point for the pre-equalizer optimization process by selecting one of the registers. In the third stage, as the training phase progresses, the receiver may communicate pre-equalization coefficient updates to the transmitter to reduce the bit error rate (BER). Such updates may also be communicated via the hidden backchannel discussed previously, or via a management interface, during the ongoing operation of the channel.

[0067] At least some system embodiments will support simultaneous updating of multiple pre-equalizer coefficient values. In at least some implementations, these systems will also support

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coarse adaptation and fine adaptation steps to accelerate the training process. The training controller may maintain status registers with fields for the sum of absolute values of current coefficient values, the total margin (i.e., difference between the sum and the predetermined limit), and the margin for each coefficient (i.e., how far the current value is from the maximum or minimum value, whichever is nearest. The fields may be bit-limited without rollover, i.e., the maximum value also represents all larger values. For example the total margin field may have four bits, while the margin field for each coefficient might have only two bits.

[0068] Fig. 8 is a flow diagram of the an illustrative communications method. As the link is first established, which may happen, e.g., during automated testing as part of the manufacturing process, when a module is inserted into a port, and/or when a cable connector is inserted into a module the training controller or link controller (hereafter, just "controller") employs an autonegotiation or backchannel communication process in block 802 to determine whether the remote transmitter has a set of preset coefficient registers. A check is made in block 804 to determine whether any such registers remain untried. If so, in block 806, the controller selects the first remaining untried register by instructing the remote transmitter to program the transmit pre-equalizer in each lane with the preset coefficient values from that register. The remote transmitter uses the pre-equalizers to transmit data, and in block 808 the receiver demodulates the multiple receive signals, e.g., with a DFE, to estimate or measure error signals (the difference between the equalized receive signals and an idealized receive signal). For training patterns, the idealized receive signal is known, whereas for transmitted data, the idealized receive signal may be estimated. The energy or average amplitude of the difference is determined in block 810 to serve as an indicator of how well the selected preset coefficient values are performing.

[0069] Blocks 804-810 are repeated until the performance of each of the preset coefficients in each register have been evaluated. Then, in block 812, the best register is selected, with the remote transmitter being instructed to use those preset coefficients as a starting point for the next phase. The remote transmitter programs the pre-equalizer with the preset coefficients from the selected register and transmits a training pattern and/or data. In block 818, the receiver demodulates the receive signals, again obtaining error signals. The demodulated data streams are later combined to form a multi-lane data stream carrying user data to a destination

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application. In block 820 the controller uses the error signals to derive adaptation information for the local receive equalizers and the remote transmit equalizers, using any applicable adaptation algorithm that may be found in the open literature. The adaptation information may be applicable to the CTLE filter, any FFE filter that may be present, and the feedback filter of the DFE (referred to herein as "local" adaptation info), as well as to the pre-equalization filter of the remote node (referred to herein as "remote" adaptation info).

[0070] In block 822, the remote adaptation information is communicated to the remote transmitter, optionally in the form of modified alignment markers having backchannel information fields for conveying the remote adaptation info. In block 824, the backchannel information from the remote transmitter is obtained, optionally by extracting the contents of the backchannel information field from the received (modified) alignment markers, yielding adaptation information for the local pre-equalizer. The modified alignment markers are then replaced with reconstructed sets of grouped PCS alignment markers. In block 826, the local adaptation information and the backchannel information are used to adjust the receive equalizers (CTLE, DFE, and FFE if any) and the local transmit pre-equalizer.

[0071] Numerous alternative forms, equivalents, and modifications will become apparent to those skilled in the art once the above disclosure is fully appreciated. For example, the foregoing description suggests specific locations and bit-widths for fields, yet any suitable location and width that can be standardized and agreed upon may be employed. For example, adaptation and status information fields may be present in each lane rather than limiting the adaption information to one lane and the status information to the other. It is intended that the claims be interpreted to embrace all such alternative forms, equivalents, and modifications that are encompassed in the scope of the appended claims.

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CLAIMS

What is claimed is:

1. A SerDes communications method that comprises, in a transceiver:
   selecting one of multiple registers to specify initial pre-equalizer coefficient values;
   updating the initial pre-equalizer coefficient values during a training phase; and
   using the updated pre-equalizer coefficient values to convey a transmit data stream.

2. The method of claim 1, wherein each of the multiple registers corresponds to a different channel model.

3. The method of claim 2, wherein at least some of the different channel models are for chip-to-module (C2M) channels with different insertion loss and package loss characteristics.

4. The method of claim 2, wherein at least some of the different channel models presume different types of receiver equalization.

5. The method of claim 1, wherein said selecting includes using the initial pre-equalizer coefficient values to determine a performance characteristic for each of the multiple registers.

6. The method of claim 1, wherein the performance characteristic is an error signal energy.

7. The method of claim 1, wherein the performance characteristic is a bit error rate.

8. The method of claim 1, further comprising updating the selected register with the updated pre-equalizer coefficient values.

9. A chip-to-module communications link that comprises a port connector coupling a port transceiver to a pluggable module transceiver, the pluggable module transceiver including:
   one or more transmit filters to each pre-equalize a corresponding serial symbol stream being transmitted to the port transceiver; and
   a controller having multiple registers, each of the multiple registers containing a set of initial coefficient values, the controller using one of the registers to set initial coefficient values for the one or more transmit filters.

10. The communications link of claim 9, wherein said one of the registers is selected by the port transceiver to specify the initial coefficient values.

11. The communications link of claim 10, wherein the port transceiver iteratively selects

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different ones of the multiple registers and determines a performance characteristic for each.

12. The communications link of claim 11, wherein the performance characteristic is an error signal energy.

13. The communications link of claim 11, wherein the performance characteristic is a bit error rate.

14. The communications link of claim 9, wherein each of the multiple registers corresponds to a different channel model.

15. The communications link of claim 14, wherein at least some of the different channel models are for chip-to-module (C2M) channels with different insertion loss and package loss characteristics.

16. The communications link of claim 14, wherein at least some of the different channel models presume different types of receiver equalization.

17. The communications link of claim 9, wherein the port transceiver generates updates for the coefficient values of the one or more transmit filters.

18. The communications link of claim 17, wherein the controller saves updated coefficient values in one of the registers.

19. A pluggable module transceiver including:

one or more transmit filters to each pre-equalize a corresponding serial symbol stream being transmitted to a port transceiver; and

a controller having multiple registers, each of the multiple registers containing a set of initial coefficient values, the controller using one of the registers to set initial coefficient values for the one or more transmit filters.

20. The transceiver of claim 19, wherein each of the multiple registers corresponds to a different channel model.

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ABSTRACT

An illustrative SerDes (serializer-deserializer) communications method embodiment may include a transceiver: selecting one of multiple registers to specify initial pre-equalizer coefficient values; updating the initial pre-equalizer coefficient values during a training phase; and using the updated pre-equalizer coefficient values to convey a transmit data stream. In an illustrative embodiment of a chip-to-module communications link, a port connector couples a port transceiver to a pluggable module transceiver, the pluggable module transceiver including: one or more transmit filters to each pre-equalize a corresponding serial symbol stream being transmitted to the port transceiver; and a controller having multiple registers, each of the multiple registers containing a set of initial coefficient values, the controller using one of the registers to set initial coefficient values for the one or more transmit filters.

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Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS
First Named Inventor/Applicant Name:	Junqing SUN
Filer:	Daniel Joseph Krueger/Theresa Evenbly
Attorney Docket Number:	20160.0031.NPUS00

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY FILING FEE (ELECTRONIC FILING)	4011	1	75	75
UTILITY SEARCH FEE	2111	1	330	330
UTILITY EXAMINATION FEE	2311	1	380	380
Pages:				
Claims:				
Miscellaneous-Filing:				
LATE FILING FEE FOR OATH OR DECLARATION	2051	1	80	80
Petition:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		865

Electronic Acknowledgement Receipt

EFS ID:	36996449
Application Number:	16552927
International Application Number:	
Confirmation Number:	1683
Title of Invention:	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS
First Named Inventor/Applicant Name:	Junqing SUN
Customer Number:	63467
Filer:	Daniel Joseph Krueger/Theresa Evenbly
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Attorney Docket Number:	20160.0031.NPUS00
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1	Application Data Sheet	Credo31_ADS-aia0014.pdf	1256079 b430366d0069decbeec70144b2e670d6de732605	no	8
Warnings:					
Information:					
2	Drawings-only black and white line drawings	C0031NPdrwV1.pdf	454594 e630638c7ec20859f5c3c710f97fb6cb3c7b047d	no	7
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3		C0031NPspecV2pre-eq_training.pdf	230031 e8c58d08139bb49db3a231649308a1e0573e1b79	yes	24
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4	Fee Worksheet (SB06)	fee-info.pdf	37480 9bdf97b74fceea7de6af039ac0f46050f82b7cb8	no	2
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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
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CONFIRMATION NO. 1683

FILING RECEIPT

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Ramey & Schwaller, LLP
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Receipt is acknowledged of this non-provisional utility 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 FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

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Assignment For Published Patent Application

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Domestic Priority data as claimed by applicant

This appln claims benefit of 62/723,701 08/28/2018

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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**** SMALL ENTITY ****
Title

SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS

Preliminary Class

375

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Title 37, Code of Federal Regulations, 5.11 & 5.15

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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.

Marvell Semiconductor, Inc. - Ex. 1002, Page 000049

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 NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/552,927	08/27/2019	Junqing SUN	20160.0031.NPUS00

CONFIRMATION NO. 1683

63467
Ramey & Schwaller, LLP
5020 Montrose Blvd.
Suite 750
Houston, TX 77006

INFORMAL NOTICE

OC000000110941492

Date Mailed: 09/10/2019

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):
  Junqing SUN
  Haoli QIAN

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/tgebre/

Marvell Semiconductor, Inc. - Ex. 1002, Page 000050

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 16/552,927

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	75		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	330		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	380		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*	x 50 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x 230 =	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	785		TOTAL	

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	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							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.

To: uspto@rameyfirm.com,wramey@rameyfirm.com,tevenbly@rameyfirm.com
From: PAIR_eOfficeAction@uspto.gov
Cc: PAIR_eOfficeAction@uspto.gov
Subject: Private PAIR Correspondence Notification for Customer Number 63467

Sep 10, 2019 03:37:19 AM

Dear PAIR Customer:

Ramey & Schwaller, LLP
5020 Montrose Blvd.
Suite 750
Houston, TX 77006
UNITED STATES

The following USPTO patent application(s) associated with your Customer Number, 63467 , have new outgoing correspondence. This correspondence is now available for viewing in Private PAIR.

The official date of notification of the outgoing correspondence will be indicated on the form PTOL-90 accompanying the correspondence.

Disclaimer:
The list of documents shown below is provided as a courtesy and is not part of the official file wrapper. The content of the images shown in PAIR is the official record.

Application	Document	Mailroom Date	Attorney Docket No.
16552927	APP.FILE.REC	09/10/2019	20160.0031.NPUS00
	M327	09/10/2019	20160.0031.NPUS00

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 with 'e-Office Action' on the subject line or call 1-866-217-9197 during the following hours:

Monday - Friday 6:00 a.m. to 12:00 a.m.

Thank you for prompt attention to this notice,

UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT APPLICATION INFORMATION RETRIEVAL SYSTEM

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

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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

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	16/552,927
Filing Date	August 27, 2019
First Named Inventor	Junqing (Phil) SUN
Title	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS
Art Unit	
Examiner Name	
Attorney Docket Number	20160.0031.NPUS00

SIGNATURE of Applicant or Patent Practitioner

Signature	/Daniel J. Krueger/	Date (Optional)	2019-10-15
Name	Daniel J. Krueger	Registration Number	42,771
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)	Credo Technology Group Limited		

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 _____ 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.

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

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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:

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):

☐ 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		Date (Optional)	
Name			
Title			

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.**

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POWER OF ATTORNEY BY APPLICANT

No more than ten (10) patent practitioners total may be appointed as set forth below by name and registration number. This page need not be submitted if appointing the Patent Practitioner(s) associated with a Customer Number (see form PTO/AIA/82B):

Name	Registration 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 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 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.

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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: 63467

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: 63467

OR

☐

Firm or Individual Name			
Address			
City		State	Zip
Country			
Telephone		Email	

Assignee Name and Address: Credo Technology Group Limited, Ugland House, Grand Cayman Ky1-1104, Cayman Islands

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		Date	2-9-2018
Name	Adam Thorngate-Gottlund	Telephone	408-664-9329 x127
Title	General Counsel		

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: Junqing (Phil) SUN and Haoli QIAN

Application No./Patent No.: 16/552,927 Filed/Issue Date: August 27, 2019

Titled: SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS

Credo Technology Group Limited, 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 _____, Frame _____, 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 by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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.

/Daniel J . Krueger/	August 14, 2019
Signature	Date
Daniel J . Krueger	42,771
Printed or Typed Name	Title or Registration 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.
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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Docket No.: 20160.0031.PZUS00

WORLDWIDE ASSIGNMENT

WHEREAS, I/WE, (hereinafter referred to as the "ASSIGNOR(S)"):

Junqing Sun, a citizen of P.R. China, residing in Fremont, California, U.S.A.
Haoli Qian, a citizen of P.R. China, residing in Fremont, California, U.S.A.

has/have invented a **SERDES PRE-EQUALIZER HAVING EFFICIENT ADAPTATION** ("Invention") for which one or more applications for patent, design registration, utility model registration, or other form of protection, rights, or title have been or will be made in certain countries ("Applications"), as further described below:

US, Application No. 62/723,701; Filed August 28, 2018;

AND WHEREAS, **CREDO TECHNOLOGY GROUP LIMITED**, (hereinafter referred to as the "ASSIGNEE"), a limited company organized under the laws of the Cayman Islands, having a place of business at Ugland House, Grand Cayman KY1-1104, Cayman Islands, is desirous of acquiring the full and exclusive right, title and interest in and to said Invention, said Applications inclusive of all ancillary rights relating thereto, any and all priority rights derived from said Applications, and all patents, design registrations, utility model registrations and other forms of protection, rights and titles relating to said Invention, in any country or countries and in respect of the whole or any part or parts of or improvements to the Invention;

NOW THEREFORE, for valuable consideration, the receipt and sufficiency of which are hereby acknowledged, ASSIGNOR(S) does/do hereby confirm that ASSIGNOR(S) has/have transferred, conveyed and assigned, and by way of further assurance does/do hereby transfer, convey and assign, any and all of ASSIGNOR(S)'s respective rights, title and interest in and to: the Invention; the Applications; any further applications for patent, design registration, utility model registration or other forms of protection, rights or titles for the whole or any part or parts of or improvements to the Invention in any country or countries ("Further Applications") together with the right to file divisional applications, substitute applications and continuation applications of any one or more of the Applications and Further Applications ("Divisionals"); the right to obtain patents, design registrations, utility model registrations and all other forms of protection, rights and titles relating to the Invention; the right in and to any patent or reissue patent relating to the Applications, Further Applications and Divisionals ("Grants"); and the right to obtain any extensions / supplementary protection certificates ("Extensions"); together with the right to bring proceedings to recover damages and/or to obtain other remedies for acts committed in respect of one or more of the aforesaid Invention, Applications, Grants, Further Applications, Divisionals and Extensions, whether such acts are committed before or after the date of this

Marvell Semiconductor, Inc. - Ex. 1002, Page 000061

Worldwide Assignment; with the intent that the Invention, Applications, Grants, Further Applications, Divisionals and Extensions are owned and enjoyed by ASSIGNEE absolutely to the full end of the term or terms for same.

ASSIGNOR(S) does/do hereby agree, upon request, to provide assistance and to execute any and all further documents, at the expense of ASSIGNEE and/or its successors and assigns (as applicable), which may be necessary or desirable to enable ASSIGNEE, and/or its successors and assigns (as applicable), to file, prosecute, bring proceedings and take other actions with respect to any and all of the Invention, Applications, Further Applications, Divisionals, Grants and Extensions, and any and all patents and registrations granted thereon and other forms of protection, rights and titles relating thereto, and ASSIGNOR(S) further agrees/agree to execute, upon request and at the expense of ASSIGNEE and/or its successors and assigns (as applicable), any and all further documents which may be necessary or desirable to vest or perfect the title of ASSIGNEE therein.

ASSIGNOR(S) does/do hereby authorize ASSIGNEE or its patent agents or attorneys to insert, above, the jurisdictions, application numbers, filing dates and any other indicia identifying the Applications when such information is available for the purpose of recording this assignment.

ASSIGNOR(S) does/do hereby authorize and request The Commissioner of Patents or any equivalent authority to issue to ASSIGNEE each and every patent, registration and other form of protection, right, and title granted upon the Applications, Further Applications, Divisionals and Extensions.

THIS WORLDWIDE ASSIGNMENT shall inure to the benefit of ASSIGNEE and its successors and assigns, and shall be binding upon ASSIGNOR(S) and their successors and permitted assigns.

DELIVERY of this Worldwide Assignment by copy, however transmitted, constitutes valid and effective delivery. This Worldwide Assignment may be executed in one or more counterparts, each of which when so executed and delivered shall be an original, and such counterparts shall together constitute one and the same instrument.

Marvell Semiconductor, Inc. - Ex. 1002, Page 000062

IN WITNESS WHEREOF, this Worldwide Assignment has been executed below by the undersigned:

Date: 7/25/2019

Junqing Sun

STATEMENT BY WITNESS

I, Sahar Zarkoohi, whose full Post Office address is

1600 Technology Drive, Fl 7, San Jose, CA 95110
(Address of Witness)

hereby declare that I was personally present and did see the above named person, personally known to me to be a person named in the Worldwide Assignment, duly sign and execute same.

Date: 7/25/19

(Signature of Witness)

Marvell Semiconductor, Inc. - Ex. 1002, Page 000063

IN WITNESS WHEREOF, this Worldwide Assignment has been executed below by the undersigned:

Date: 07/25/2019

Haoli Qian

STATEMENT BY WITNESS

I, Sahar Zarabooki, whose full Post Office address is

1600 Technology Drive, FL 7, San Jose, CA 95110
(Address of Witness)

hereby declare that I was personally present and did see the above named person, personally known to me to be a person named in the Worldwide Assignment, duly sign and execute same.

Date: 7/25/19

(Signature of Witness)

Marvell Semiconductor, Inc. - Ex. 1002, Page 000064

Electronic Acknowledgement Receipt

EFS ID:	37461403
Application Number:	16552927
International Application Number:	
Confirmation Number:	1683
Title of Invention:	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS
First Named Inventor/Applicant Name:	Junqing SUN
Customer Number:	63467
Filer:	Daniel Joseph Krueger/Theresa Evenbly
Filer Authorized By:	Daniel Joseph Krueger
Attorney Docket Number:	20160.0031.NPUS00
Receipt Date:	15-OCT-2019
Filing Date:	27-AUG-2019
Time Stamp:	15:46:44
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	Executed_Declaration_Sun.pdf	378648 3ac79de97196b06dba62287e1499816ea470ec91	no	1

Warnings:

Information:					
2	Oath or Declaration filed	Executed_Declaration_Qian.pdf	371867 f3d1d8857db9a3e5f33cee50479ed9e0baf0c150	no	1
Warnings:					
Information:					
3	Power of Attorney	Xtml-POAaia0082.pdf	221545 d79f413a69552acf64e09f2876149468694a1b3b	no	4
Warnings:					
Information:					
4	Power of Attorney	Executed_Gen_POA.pdf	147741 5b3b108513db50144c0821f8db29774017aab720	no	1
Warnings:					
Information:					
5	Assignee showing of ownership per 37 CFR 3.73	Stmt3-73aia0096.pdf	735933 9ce7d1926f0b25466e545b9fa1157c5869849c6b	no	3
Warnings:					
Information:					
6	Assignee showing of ownership per 37 CFR 3.73	Executed_Assignment.pdf	1047902 bbb72c7c5e0c27ba1e650bca8b9fed1eee760476	no	4
Warnings:					
Information:					
			Total Files Size (in bytes):	2903636	

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

New Applications Under 35 U.S.C. 111

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

National Stage of an International Application under 35 U.S.C. 371

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

New International Application Filed with the USPTO as a Receiving Office

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

PTO/AIA/01 (06-12)
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of invention	SERDES PRE-EQUALIZER HAVING EFFICIENT ADAPTATION

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 62/723,701 filed on August 28, 2018.

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 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: Junqing Sun Date (Optional): 7/25/2019

Signature: [signature]

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 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. This collection is estimated to take 1 minute 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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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	SERDES PRE-EQUALIZER HAVING EFFICIENT ADAPTATION

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 62723701 filed on August 28, 2018.

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 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: Haoli Qian Date (Optional): _____

Signature: _____

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 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. This collection is estimated to take 1 minute 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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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/552,927	08/27/2019	Junqing SUN	20160.0031.NPUS00

CONFIRMATION NO. 1683

63467
Ramey & Schwaller, LLP
Ramey & Schwaller
5020 Montrose Blvd.
Suite 750
Houston, TX 77006

POA ACCEPTANCE LETTER

OC000000111962658

Date Mailed: 10/18/2019

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/15/2019.

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.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/mbeyene/

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To: uspto@rameyfirm.com,wramey@rameyfirm.com,tevenbly@rameyfirm.com
From: PAIR_eOfficeAction@uspto.gov
Cc: PAIR_eOfficeAction@uspto.gov
Subject: Private PAIR Correspondence Notification for Customer Number 63467

Oct 18, 2019 03:40:47 AM

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Ramey & Schwaller, LLP
Ramey & Schwaller
5020 Montrose Blvd.
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UNITED STATES

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Application	Document	Mailroom Date	Attorney Docket No.
16552927	N570	10/18/2019	20160.0031.NPUS00

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www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/552,927	08/27/2019	Junqing SUN	20160.0031.NPUS00

CONFIRMATION NO. 1683

63467
Ramey & Schwaller, LLP
Ramey & Schwaller
5020 Montrose Blvd.
Suite 800
Houston, TX 77006

PUBLICATION NOTICE



Title:SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS

Publication No.US-2020-0076651-A1
Publication Date:03/05/2020

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/.

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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 https://portal.uspto.gov/pair/PublicPair. 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

Marvell Semiconductor, Inc. - Ex. 1002, Page 000072

To: uspto@rameyfirm.com,wramey@rameyfirm.com,tevenbly@rameyfirm.com
From: PAIR_eOfficeAction@uspto.gov
Cc: PAIR_eOfficeAction@uspto.gov
Subject: Private PAIR Correspondence Notification for Customer Number 63467

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Dear PAIR Customer:

Ramey & Schwaller, LLP
Ramey & Schwaller
5020 Montrose Blvd.
Suite 800
Houston, TX 77006
UNITED STATES

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Application	Document	Mailroom Date	Attorney Docket No.
16552927	NTC.PUB	03/05/2020	20160.0031.NPUS00

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	16552927
Filing Date	2019-08-27
First Named Inventor	Junqing SUN
Art Unit	2632
Examiner Name	Malek, Leila
Attorney Docket Number	20160.0031.NPUS00

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	8301036	B2	2012-10-30	He	
	2	9071479	B2	2015-06-30	Qian et al.	
	3	9935800	B1	2018-04-03	He	
	4	9385859	B2	2016-07-05	Kuan et al.	

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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	20200076651	A1	2020-03-05	SUN et al.	
	2	20130343400	A1	2014-03-27	Lusted et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16552927
	Filing Date	2019-08-27
	First Named Inventor	Junqing SUN
	Art Unit	2632
	Examiner Name	Malek, Leila
	Attorney Docket Number	20160.0031.NPUS00

	3	20140086264	A1	2014-03-27	Lusted et al.	
	4	20140146833	A1	2014-05-29	Lusted et al.	
	5	20150003505	A1	2015-01-01	Lusted et al.	
	6	20160337114	A1	2016-11-17	Baden et al.	

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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]
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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	Information Technology - Open Systems Interconnection - Basic Reference Model: The Basic Model, 1994	
	2	International Search Report dated December 6, 2017 in International Application No. PCT/CN2017/075961	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16552927
	Filing Date	2019-08-27
	First Named Inventor	Junqing SUN
	Art Unit	2632
	Examiner Name	Malek, Leila
	Attorney Docket Number	20160.0031.NPUS00

	3	Non-Final Office Action dated January 24, 2018 in 15/487,045	
	4	Reed-Solomon Forward Error Correction (RS-FEC) Sublayer for 100GBASE-R PHYs.	
	5	Notice of Allowance dated June 8, 2018 in Application No. 15/487,045	
	6	"Physical Coding Sublayer (PCS) for 64B/66B, type 50GBASE-R" Draft Amendment to IEEE Std 802.3-2015, February 3, 2017, pp. 132-141, 10 pgs.	
	7	"Physical Medium Attachment (PMA) sublayer, Physical Medium Dependent (PMD) sublayer, and baseband medium, type 1000GBASE-KP4," IEEE Standard for Ethernet, Section Six, pp. 481-519, 39 pgs.	
	8	"Physical Medium Dependent (PMD) sublayer and baseband medium, type 50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4," Draft Amendment to IEEE Std 802.3-2015, February 3, 2017, pp. 184-215, 32 pgs.	
	9	"Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 50GBASE-R PHYs," Draft Amendment to IEEE Std 802.3-2015, February 3, 2017, pp. 142-159, 18 pgs.	

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	Application Number	16552927
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	Attorney Docket Number	20160.0031.NPUS00

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INTERNATIONAL STANDARD

ISO/IEC 7498-1

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Information technology — Open Systems Interconnection — Basic Reference Model: The Basic Model

Technologies de l'information — Modèle de référence de base pour l'interconnexion de systèmes ouverts (OSI): Le modèle de base



Reference number
ISO/IEC 7498-1:1994(E)

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

International Standard ISO/IEC 7498-1 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, in collaboration with ITU-T. The identical text is published as ITU-T Recommendation X.200.

This second edition, along with parts 2, 3 and 4, cancels and replaces the first edition (ISO 7498:1984), which has been technically revised.

ISO/IEC 7498 consists of the following parts, under the general title *Information technology — Open Systems Interconnection — Basic Reference Model*:

— *Part 1: The Basic Model*

— *Part 2: Security Architecture*

— *Part 3: Naming and addressing*

— *Part 4: Management framework*

Annex B forms an integral part of this part of ISO/IEC 7498. Annex A is for information only.

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Introduction

This reference model provides a common basis for the coordination of standards development for the purpose of systems interconnection, while allowing existing standards to be placed into perspective within the overall reference model. It also identifies areas for developing and improving standards and provides a common reference for maintaining consistency among all related standards. The text was developed jointly with ITU-T and the main intent of this revision is to introduce the joint text, which incorporates inclusion of the concept of connectionless transmission, in addition to a number of technical and editorial refinements.

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INTERNATIONAL STANDARD

CCITT RECOMMENDATION

INFORMATION TECHNOLOGY – OPEN SYSTEMS INTERCONNECTION – BASIC REFERENCE MODEL: THE BASIC MODEL

1 Scope

1.1 The purpose of this Reference Model of Open Systems Interconnection is to provide a common basis for the coordination of standards development for the purpose of systems interconnection, while allowing existing standards to be placed into perspective within the overall Reference Model.

1.2 The term Open Systems Interconnection (OSI) qualifies standards for the exchange of information among systems that are "open" to one another for this purpose by virtue of their mutual use of the applicable standards.

1.3 The fact that a system is open does not imply any particular systems implementation, technology or means of interconnection, but refers to the mutual recognition and support of the applicable standards.

1.4 It is also the purpose of this Reference Model to identify areas for developing or improving standards, and to provide a common reference for maintaining consistency of all related standards. It is not the intent of this Reference Model either to serve as an implementation specification, or to be a basis for appraising the conformance of actual implementations, or to provide a sufficient level of detail to define precisely the services and protocols of the interconnection architecture. Rather, this Reference Model provides a conceptual and functional framework which allows international teams of experts to work productively and independently on the development of standards for each layer of the Reference Model for OSI.

1.5 The Reference Model has sufficient flexibility to accommodate advances in technology and expansion in user demands. This flexibility is also intended to allow the phased transition from existing implementations to OSI standards.

1.6 While the scope of the general architectural principles required for OSI is very broad, this Reference Model is primarily concerned with systems comprising terminals, computers, and associated devices and the means for transferring information between such systems. Other aspects of OSI requiring attention are described briefly (see 4.2).

1.7 The description of the Basic Reference Model of OSI is developed in stages:

1.8 Clause 4 establishes the reasons for Open Systems Interconnection, defines what is being connected, the scope of the interconnection, and describes the modelling principles used in OSI.

1.9 Clause 5 describes the general nature of the architecture of the Reference Model; namely that it is layered, what layering means, and the principles used to describe layers.

1.10 Clause 6 names, and introduces the specific layers of the architecture.

1.11 Clause 7 provides the description of the specific layers.

1.12 Clause 8 provides the description of Management Aspects of OSI.

1.13 Clause 9 specifies compliance and consistency with the OSI Reference Model.

1.14 An indication of how the layers were chosen is given in Annex A to this Basic Reference Model.

1.15 Additional aspects of this Reference Model beyond the basic aspects are described in several parts. The first part describes the Basic Reference Model. The second part describes the architecture for OSI Security. The third part describes OSI Naming and Addressing. The fourth describes OSI System Management.

1.16 The Basic Reference Model serves as a framework for the definition of services and protocols which fit within the boundaries established by the Reference Model.

1.17 In those few cases where a feature is explicitly marked (optional) in the Basic Reference Model it should remain optional in the corresponding service or protocol (even if at a given instant the two cases of the option are not yet documented).

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1.18 This Reference Model does not specify services and protocols for OSI. It is neither an implementation specification for systems, nor a basis for appraising the conformance of implementations.

1.19 For standards which meet the OSI requirements, a small number of practical subsets are defined from optional functions, to facilitate implementation and compatibility.

2 Definitions

Definitions of terms are included at the beginning of individual clauses and sub-clauses. An index of these terms is provided in Annex B for easy reference.

3 Notation

3.1 Layers are introduced in clause 5. An (N)-, (N+1)- and (N–1)- notation is used to identify and relate adjacent layers:

(N)-layer: any specific layer;

(N+1)-layer: the next higher layer;

(N–1)-layer: the next lower layer.

This notation is also used for other concepts in the model which are related to these layers, for example (N)-protocol, (N+1)-service.

3.2 Clause 6 introduces names for individual layers. When referring to these layers by name, the (N)-, (N+1)- and (N–1)- prefixes are replaced by the names of the layers, for example transport-protocol, session-entity, and network-service.

4 Introduction to Open Systems Interconnection (OSI)

NOTE – The general principles described in clauses 4 and 5 hold for all layers of the Reference Model, unless layer specific statements to the contrary are made in clauses 6 and 7.

4.1 Definitions

4.1.1 real system: A set of one or more computers, the associated software, peripherals, terminals, human operators, physical processes, information transfer means, etc., that forms an autonomous whole capable of performing information processing and/or information transfer.

4.1.2 real open system: A real system which complies with the requirements of OSI standards in its communication with other real systems.

4.1.3 open system: The representation within the Reference Model of those aspects of a real open system that are pertinent to OSI.

4.1.4 application process: An element within a real open system which performs the information processing for a particular application.

4.1.5 Open System Interconnection Environment (OSIE): An abstract representation of the set of concepts, elements, functions, services, protocols, etc., as defined by the OSI Reference Model and the derived specific standards which, when applied, enable communications among open systems.

4.1.6 Local System Environment (LSE): An abstract representation of that part of the real system that is not pertinent to OSI.

NOTE – The LSE may include functions necessary for non-OSI communication.

4.1.7 application-process-invocation: A specific utilization of part or all of the capabilities of a given application process in support of a specific occasion of information processing.

4.1.8 application-process-type: A description of a class of application processes in terms of a set of information processing capabilities.

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4.2 Open System Interconnection Environment

4.2.1 In the concept of OSI, a real system is a set of one or more computers, associated software, peripherals, terminals, human operators, physical processes, information transfer means, etc., that forms an autonomous whole capable of performing information processing and/or information transfer.

4.2.2 An application process is an element within a real open system which performs the information processing for a particular application.

4.2.3 Application processes can represent manual processes, computerized processes or physical processes.

4.2.4 Some examples of application processes that are applicable to this open system definition are the following:

a) a person operating a banking terminal is a manual application-process;

b) a FORTRAN program executing in a computer center and accessing a remote database is a computerized application-process; the remote database management systems server is also an application-process; and

c) a process control program executing in a dedicated computer attached to some industrial equipment and linked into a plant control system is a physical application-process.

4.2.5 An application process represents a set of resources, including processing resources, within a real open system that may be used to perform a particular information processing activity. An application process may organize its interactions with other application processes in whatever way is necessary to achieve a particular information processing goal: no constraints are imposed by this Reference Model either on the form of these interactions or on the possible relationships that may exist between them.

4.2.6 The activity of a given application process is represented by one or more application process invocations. Cooperation between application processes takes place via relationships established among application process invocations. At a particular time, an application process may be represented by none, one or more application process invocations. An application process invocation is responsible for coordinating its interactions with other application process invocations. Such coordination is outside the scope of this Reference Model.

4.2.7 OSI is concerned with the exchange of information between open systems (and not the internal functioning of each individual real open system).

4.2.8 As shown in Figure 1, the physical media for Open Systems Interconnection provides the means for the transfer of information between open systems.

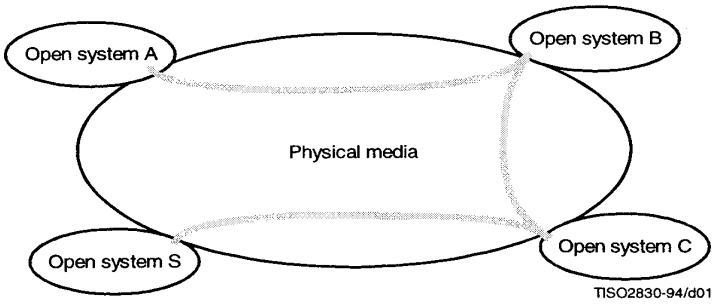


Figure 1 – Open systems connected by physical media

4.2.9 OSI is concerned only with the interconnection of systems. All other aspects of systems which are not related to interconnection are outside the scope of OSI.

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4.2.10 OSI is concerned not only with the transfer of information between systems, i.e. transmission, but also with their capability to interwork to achieve a common (distributed) task. In other words, OSI is concerned with the interconnection aspects of cooperation[1)] between systems, which is implied by the expression "systems interconnection."

4.2.11 The objective of OSI is to define a set of standards to enable real open systems to cooperate. A system which complies with the requirements of applicable OSI standards in its cooperation with other systems is termed a real open system.

4.2.12 The design intent of the OSI standards is to specify a set of standards that make it possible for autonomous systems to communicate. Any equipment which communicates in conformance with all applicable OSI protocol standards is a real world equivalent of the model concept "open system". Equipment that is in the "terminal" category, that is, one that requires human intervention for the dominant parts of information processing, may satisfy the conditions of the previous sentences when the appropriate OSI standards are employed in communication with other open systems.

4.3 Modelling the OSI Environment

4.3.1 The development of OSI standards, i.e. standards for the interconnection of real open systems, is assisted by the use of abstract models. To specify the external behavior of interconnected real open systems, each real open system is replaced by a functionally equivalent abstract model of a real open system called an open system. Only the interconnection aspects of these open systems would strictly need to be described. However to accomplish this, it is necessary to describe both the internal and external behavior of these open systems. Only the external behavior of open systems is retained for the definition of standards for real open systems. The description of the internal behavior of open systems is provided in the Basic Reference Model only to support the definition of the interconnection aspects. Any real system which behaves externally as an open system can be considered to be a real open system.

4.3.2 This abstract modelling is used in two steps.

4.3.3 First, basic elements of open systems and some key decisions concerning their organization and functioning, are developed. This constitutes the Basic Reference Model of Open Systems Interconnection described in this Recommendation | Part of this International Standard.

4.3.4 Then, the detailed and precise description of the functioning of the open system is developed in the framework formed by the Basic Reference Model. This constitutes the services and protocols for OSI which are the subject of other Recommendations and/or International Standards.

4.3.5 It should be emphasized that the Basic Reference Model does not, by itself, specify the detailed and precise functioning of the open system and, therefore, it does not specify the external behavior of real open systems and does not imply the structure of the implementation of a real open system.

4.3.6 The reader not familiar with the technique of abstract modelling is cautioned that those concepts introduced in the description of open systems constitute an abstraction despite a similiar appearance to concepts commonly found in real systems. Therefore, real open systems need not be implemented as described by the Model.

---

1) Cooperation among open systems involves a broad range of activities of which the following have been identified:

a) interprocess communication, which concerns the exchange of information and the synchronization of activity between OSI application processes;

b) data representation, which concerns all aspects of the creation and maintenance of data descriptions and data transformations for reformatting data exchanged between open systems;

c) data storage, which concerns storage media, and file and database systems for managing and providing access to data stored on the media;

d) process and resource management, which concerns the means by which OSI application processes are declared, initiated and controlled, and the means by which they acquire OSI resources;

e) integrity and security, which concern information processing constraints that have to be preserved or assured during the operation of the open systems; and

f) program support, which concerns the definition, compilation, linking, testing, storage, transfer, and access to the programs executed by OSI application-processes.

Some of these activities may imply exchange of information between the interconnected open systems and their interconnection aspects may, therefore, be of concern to OSI.

This Basic Reference Model covers the elements of OSI aspects of these activities which are essential for early development of OSI standards.

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4.3.7 Throughout the remainder of this Basic Reference Model, only the aspects of real systems and application-processes which lie within the OSI Environment (OSIE) are considered. Their interconnection is illustrated throughout this Reference Model as depicted in Figure 2.

4.3.8 The extent of the application of the OSIE concept through the use of OSI standards may result in subsets of the OSIE which corresponds to partially disjoint sets of real open systems, which are not physically capable of OSI communication between them.

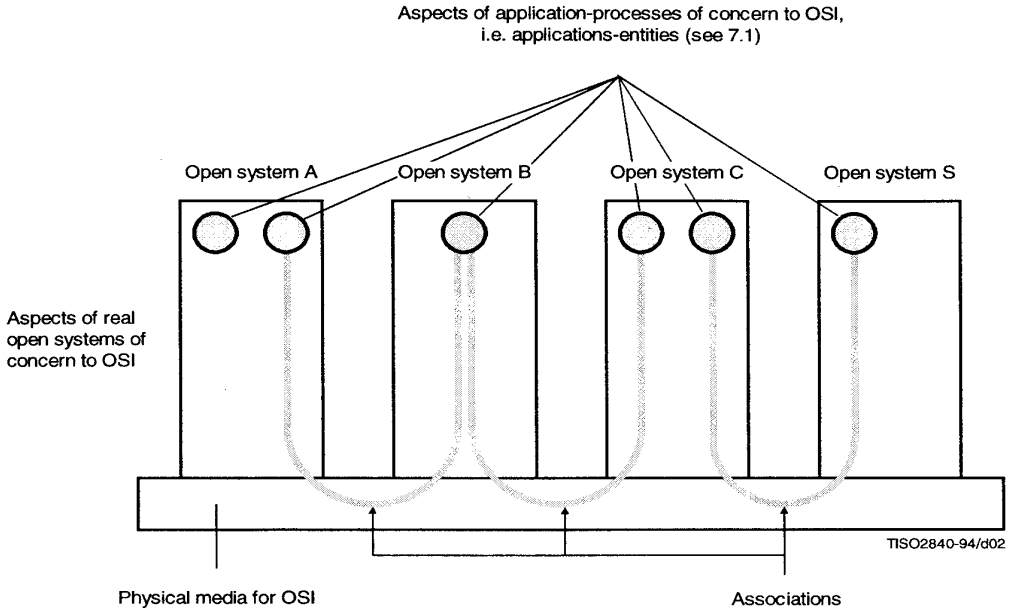


Figure 2 – Basic elements of OSI

5 Concepts of a layered architecture

5.1 Introduction

5.1.1 Clause 5 sets forth the architectural concepts that are applied in the development of the Reference Model of Open Systems Interconnection. Firstly, the concept of a layered architecture (with layers, entities, service-access-points, protocols, connections, etc.) is described. Secondly, identifiers are introduced for entities, service-access-points, and connections. Thirdly, service-access-points and data-units are described. Fourthly, elements of layer operation are described including connections, transmission of data, and error functions. Then, routing aspects are introduced and finally, management aspects are discussed.

5.1.2 The concepts described in clause 5 are those required to describe the Reference Model of Open Systems Interconnection. However, not all of the concepts described are employed in each layer of the Reference Model.

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5.1.3 Four elements are basic to the Reference Model (see Figure 2):

a) open systems;

b) the application-entities which exist within the OSI Environment (see 7.1);

c) the associations (see 5.3) which join the application-entities and permit them to exchange information; and

d) the physical media for OSI.

NOTE – Security aspects which are also general architectural elements of protocols are discussed in CCITT Rec. X.800 | ISO 7498-2.

5.2 Principles of layering

5.2.1 Definitions

5.2.1.1 (N)-subsystem: An element in a hierarchical division of an open system which interacts directly only with elements in the next higher division or the next lower division of that open system.

5.2.1.2 (N)-layer: A subdivision of the OSI architecture, constituted by subsystems of the same rank (N).

5.2.1.3 peer-(N)-entities: Entities within the same (N)-layer.

5.2.1.4 sublayer: A subdivision of a layer.

5.2.1.5 (N)-service: A capability of the (N)-layer and the layers beneath it, which is provided to (N+1)-entities at the boundary between the (N)-layer and the (N+1)-layer.

5.2.1.6 (N)-facility: A part of an (N)-service.

5.2.1.7 (N)-function: A part of the activity of (N)-entities.

5.2.1.8 (N)-service-access-point, (N)-SAP: The point at which (N)-services are provided by an (N)-entity to an (N+1)-entity.

5.2.1.9 (N)-protocol: A set of rules and formats (semantic and syntactic) which determines the communication behavior of (N)-entities in the performance of (N)-functions.

5.2.1.10 (N)-entity-type: A description of a class of (N)-entities in terms of a set of capabilities defined for the (N)-layer.

5.2.1.11 (N)-entity: An active element within an (N)-subsystem embodying a set of capabilities defined for the (N)-layer that corresponds to a specific (N)-entity-type (without any extra capabilities being used).

5.2.1.12 (N)-entity-invocation: A specific utilization of part or all of the capabilities of a given (N)-entity (without any extra capabilities being used).

5.2.2 Description

5.2.2.1 The basic structuring technique in the Reference Model of Open Systems Interconnection is layering. According to this technique, each open system is viewed as logically composed of an ordered set of (N)-subsystems, represented for convenience in the vertical sequence shown in Figure 3. Adjacent (N)-subsystems communicate through their common boundary. (N)-subsystems of the same rank (N) collectively form the (N)-layer of the Reference Model of Open Systems Interconnection. There is one and only one (N)-subsystem in an open system for layer N. An (N)-subsystem consists of one or several (N)-entities. Entities exist in each (N)-layer. Entities in the same (N)-layer are termed peer-(N)-entities. Note that the highest layer does not have an (N+1)-layer above it and the lowest layer does not have an (N–1)-layer below it.

5.2.2.2 Not all peer-(N)-entities need or even can communicate. There may be conditions which prevent this communication (for example: they are not in interconnected open systems, or they do not support the same protocol subsets). Communication among peer-(N)-entities which reside in the same (N)-subsystem is provided by the LSE and therefore is out of the scope of OSI.

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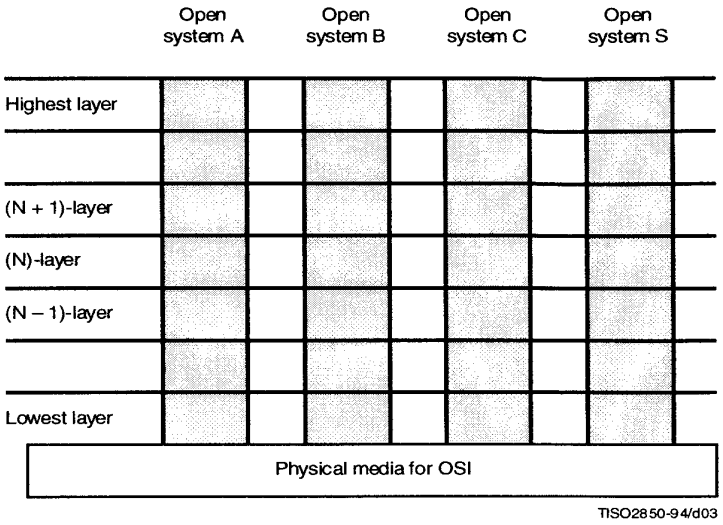


Figure 3 – Layering in cooperating open systems

NOTES

1 The distinction between the type of some object and an instance of that object is a distinction of significance for OSI. A type is a description of a class of objects. An instance of this type is any object that conforms to this description. The instances of the same type constitute a class. A type, and any instances of this type can be referred to by an individual name. Each nameable instance and the type to which this instance belongs carry distinguishable names.

For example, given that a programmer has written a computer program, that programmer has generated a type of something where instances of that type are created every time that particular program is invoked into execution by a computer. Thus, a FORTRAN compiler is a type and each occasion where a copy of that program is invoked in a data processing machine one displays an instance of that program.

The general concept of instantiation applies within OSI: Consider now an (N)-entity in the OSI context. It too, has two aspects, a type and a collection of invocations. The type of an (N)-entity is defined by description of the specific set of (N)-layer functions it is able to perform. An invocation of that type of (N)-entity is a specific invocation of whatever it is within the relevant open system that provides the (N)-layer functions called for by its type for a particular occasion of communication. It follows from these observations that (N)-entities refer only to the properties of an association between peer (N)-entities, while an (N)-entity-invocation refers to the specific, dynamic occasions of actual information exchange.

It is important to note that actual communication occurs only between (N)-entity-invocations at all layers. In the connection-mode (see 5.3.3), it is only at connection establishment time (or its logical equivalent during a recovery process) that (N)-entities are explicitly relevant. An actual connection is always made with a specific (N)-entity-invocation, although the request for connection is often made to an arbitrary (N)-entity (of a specific type). If an (N)-entity-invocation is aware of the name of its peer-(N)-entity-invocation, it is able to request another connection to that (N)-entity-invocation.

2 It may be necessary to further divide a layer into small substructures called sublayers and to extend the technique of layering to cover other dimensions of OSI. A sublayer is defined as a grouping of functions in a layer which may be bypassed. The bypassing of all the sublayers of a layer is not allowed. A sublayer uses the entities and communication services of the layer. The detailed definition or additional characteristics of a sublayer are for further study.

5.2.2.3 Except for the highest layer, each (N)-layer provides (N+1)-entities in the (N+1)-layer with an (N)-service at (N)-SAP(s). The properties of (N)-SAPs are described in 5.5. The highest layer is assumed to represent all possible uses of the (N)-service which are provided by the lower layers.

NOTE – Not all open systems provide the initial source or final destination of data. Such open systems need not contain the higher layers of the architecture (see Figure 12).

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5.2.2.4 Each service provided by an (N)-layer may be tailored by the selection of one or more (N)-facilities which determine the attributes of that service. When a single (N)-entity cannot by itself fully support a service requested by an (N+1)-entity it calls upon the co-operation of other (N)-entities to help complete the service request. In order to co-operate, (N)-entities in any layer, other than those in the lowest layer, communicate by means of the set of services provided by the (N–1)-layer (see Figure 4). The entities in the lowest layer are assumed to communicate directly via the physical media which connect them.

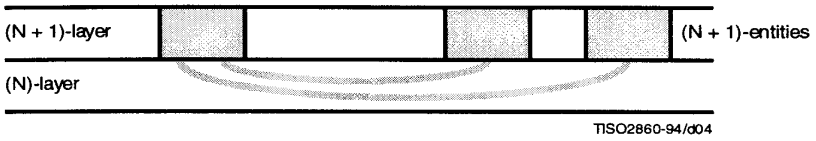


Figure 4 – (N + 1)-entities in the (N + 1)-layer communicate through the (N)-layer

5.2.2.5 The services of an (N)-layer are provided to the (N+1)-layer using the (N)-functions performed within the (N)-layer and as necessary the services available from the (N–1)-layer.

NOTE – This does not preclude the case where no protocol action is required in the (N)-layer to support a given (N)-facility because it is already available at the (N–1)-service boundary. However, null functionality of the complete (N)-protocol is not allowed.

5.2.2.6 An (N)-entity may provide services to one or more (N+1)-entities and use the services of one or more (N–1)-entities. An (N)-service-access-point is the point at which a pair of entities in adjacent layers use or provide services (see Figure 7).

5.2.2.7 Cooperation between (N)-entities is governed by one or more (N)-protocols. The entities and protocols within a layer are illustrated in Figure 5.

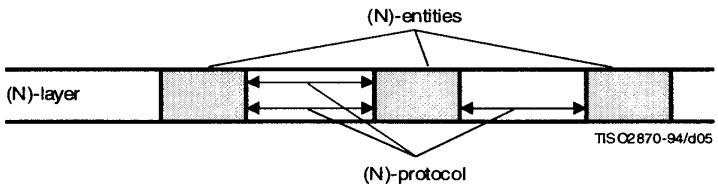


Figure 5 – (N)-protocols between (N)-entities

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5.3 Communication between peer-entities

5.3.1 Definitions

5.3.1.1 (N)-association: A cooperative relationship among (N)-entity-invocations.

5.3.1.2 (N)-connection: An association requested by an (N+1)-entity for the transfer of data betweeen two or more (N+1)-entities. The association is established by the (N)-layer and provides explicit identification of a set of (N)-data-transmissions and agreement concerning the (N)-data-transmission services to be provided for the set.

5.3.1.3 (N)-connection-endpoint: A terminator at one end of an (N)-connection within an (N)-service-access-point.

5.3.1.4 multi-endpoint-connection: A connection with more than two connection-endpoints.

5.3.1.5 correspondent (N)-entities: (N)-entities with an (N–1)-connection between them.

5.3.1.6 (N)-relay: An (N)-function by means of which an (N)-entity forwards data received from one peer-(N)-entity to another peer-(N)-entity.

5.3.1.7 (N)-data-source: An (N)-entity that sends (N–1)-service-data-units (see 5.6.1.7) on an (N–1)-connection.[2)]

5.3.1.8 (N)-data-sink: An (N)-entity that receives (N–1)-service-data-units on an (N–1)-connnection[2)]

5.3.1.9 (N)-data-transmission: An (N)-facility which conveys (N)-service-data-units from one (N+1)-entity to one or more (N+1)-entities.

5.3.1.10 (N)-duplex-transmission: (N)-data-transmission in both directions at the same time.[2)]

5.3.1.11 (N)-half-duplex-transmission: (N)-data-transmission in either direction, one direction at a time; the choice of direction is controlled by an (N+1)-entity.[2)]

5.3.1.12 (N)-simplex-transmission: (N)-data-transmission in one pre-assigned direction.[2)]

5.3.1.13 (N)-data-communication: An (N)-function which transfers (N)-protocol-data-units (see 5.6.1.3) according to an (N)-protocol, over one or more (N–1)-connections.[2)]

5.3.1.14 (N)-two-way-simultaneous-communication: (N)-data-communication in both directions at the same time.

5.3.1.15 (N)-two-way-alternate-communication: (N)-data-communication in both directions, one direction at a time.

5.3.1.16 (N)-one-way-communication: (N)-data-communication in one pre-assigned direction.

5.3.1.17 (N)-connection-mode transmission: (N)-data-transmission in the context of an (N)-connection.

5.3.1.18 (N)-connectionless-mode transmission: (N)-data-transmission not in the context of an (N)-connection and not required to maintain any logical relationship between (N)-service-data-units.

5.3.2 Description

5.3.2.1 For information to be exchanged between two or more (N+1)-entities, an association **is** established between them in the (N)-layer using an (N)-protocol.

NOTE – Classes of protocols may be defined within the (N)-protocols.

5.3.2.2 The rules and formats of an (N)-protocol are instantiated in an (N)-subsystem by an (N)-entity. An (N)-entity may support one or more (N)-protocols. (N)-entities may support (N)-protocols which are connection-mode or connectionless-mode or both. (N)-entities when supporting connection-mode maintain the binding of (N)-connections to the appropriate (N+1)-entities at the appropriate (N)-SAPs. (N)-entities when supporting connectionless-mode maintain a binding with the appropriate (N)-SAPs for delivering the connectionless data to the (N+1)-entities.

5.3.2.3 (N+1)-entities can communicate only by using the services of the (N)-layer. There are instances where services provided by the (N)-layer do not permit direct access between all of the (N+1)-entities which have to communicate. If this is the case communication can still occur if some other (N+1)-entities can act as relays between them (see Figure 6).

[2)] These definitions are not for use in this Basic Reference Model, but are for use in other OSI standards.

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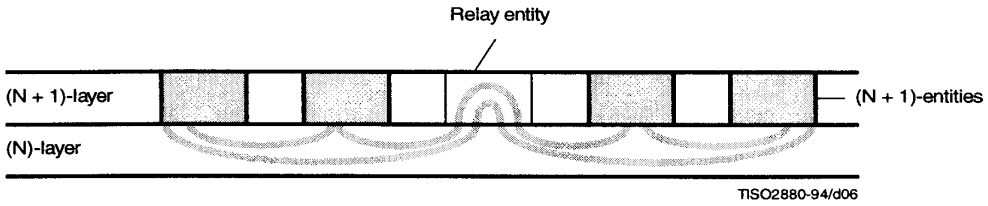


Figure 6 – Communication through a relay

5.3.2.4 The fact that communication is relayed by a chain of (N+1)-entities is known neither by the (N)-layer nor by the (N+2)-layer.

5.3.3 Modes of communication

5.3.3.1 Introduction

5.3.3.1.1 An (N)-layer may offer a connection-mode service, a connectionless-mode service, or both, to the (N+1)-layer, using the service or services provided by the (N–1)-layer. Any instance of transmission between the (N+1)-entities must utilize the same mode of (N)-service.

5.3.3.1.2 Both the (N)-connection-mode service and the (N)-connectionless-mode service are characterised by the facilities which they offer to, and the quality of service seen by, the (N+1)-entities. For both the (N)-connection-mode service and the (N)-connectionless-mode service, functions may be provided by the (N)-layer to enhance the facilities offered to, and the quality of service seen by the (N+1)-entities over those which are offered to the (N)-layer by the (N–1)-layer and, if necessary, to convert between one mode of service and another.

5.3.3.1.3 Since connection-mode transmission and connectionless-mode transmission are complementary concepts, they are best understood in juxtaposition, particularly since connectionless-mode transmission is defined most easily in relationship to the concept of a connection.

5.3.3.1.4 In order for (N+1)-entities to be able to communicate using an (N)-connection-mode service or an (N)-onnectionless-mode service it is essential that a pre-arranged association exists between them, constituted by the pre-knowledge which it is essential that each (N+1)-entity has of the others in order at least to initiate the use of the service. This association is established in ways which are not detailed in this Basic Reference Model and comprises four elements:

a) knowledge of the addresses of the peer-(N)-entities involved;

b) knowledge of a protocol agreed by the peer-(N)-entities for use at least to initiate communication;

c) knowledge of the availability for communication of the peer-(N)-entities;

d) knowledge of the quality of service available from the (N)-service.

NOTE – The pre-knowledge constituting a pre-arranged association can be acquired in many ways; some examples are listed below:

a) from information acquired manually when contracts are exchanged with a service provider;

b) from information which a network administration may provide in a directory or enquiry database;

c) from information that may be learned from previous instances of communication;

d) from information that may be provided dynamically through the operation of management protocols.

The total pre-knowledge constituting a pre-arranged association is likely to be acquired in a combination of the above ways.

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5.3.3.2 Connection mode

5.3.3.2.1 A connection is an association established for the transfer of data between two or more peer-(N)-entities. This association binds the peer-(N)-entities together with the (N–1)-entities in the next lower layer. The ability to establish and release a connection and to transfer data over it is provided to the (N)-entities in a given (N)-layer by the next lower layer as a connection-mode service. The use of a connection-mode service by peer-(N)-entities proceeds through three distinct phases:

a) connection establishment;

b) data transfer; and

c) connection release.

5.3.3.2.2 In addition to the clearly distinguishable lifetime exhibited by these phases,a connection has the following fundamental characteristics:

a) it involves establishing and maintaining a two or more party agreement concerning the transmission of data among the peer-(N)-entities concerned, and using the provider of the (N–1)-service;

b) it allows the negotiation between all the parties concerned of the parameters and options that will govern the transmission of data;

c) it provides connection identification by means of which the overheads involved in address resolution and transmission can be avoided on data transfers;

d) it provides a context within which successive units of data transmitted between the peer-entities are logically related, and makes it possible to maintain sequence and provide flow control for those transmissions.

5.3.3.2.3 The characteristics of connection-mode transmission are particularly attractive in applications which call for relatively long-lived, stream-oriented interactions between entities in stable configurations. Examples are provided by direct terminal use of a remote computer, file transfer, and long-term attachment of remote job entry stations. In these cases, the entities involved initially discuss their requirements and agree to the terms of their interaction, reserving whatever resources they may need, transfer a series of related units of data to accomplish their mutual objective, and explicitly end their interaction, releasing the previously reserved resources. The properties of connection-mode transmission are also relevant in a wide range of other applications.

5.3.3.2.4 Connection-mode transmission is accomplished through the use of (N)-connections. (N)-connections are provided by the (N)-layer between two or more (N)-service-access-points. The terminator of an (N)-connection at an (N)-service-access-point is called an (N)-connection-endpoint. An (N)-connection is provided by the (N)-layer between two or more (N)-service-access-points at the request of a calling (N+1)-entity in support of the (N+1)-entities attached to the (N)-service-access-points involved in the (N)-connection. An (N)-connection with more than two endpoints is termed a multi-endpoint-connection. (N)-entities with a connection between them are termed correspondent (N)-entities.

NOTE – Data transfer using an (N)-connection-mode service involves the establishment of an (N)-connection prior to the data transfer. This dynamically sets up an association between the (N+1)-entities and the (N)-connection-mode service in addition to the association identified in 5.3.2. This association involves elements which are not part of the pre-arranged association described in 5.3.3.1.4, in particular:

a) knowledge of the willingness of the peer-(N)-entity or entities to undertake a specific communication, and of the willingness of the underlying service to support it and;

b) the ability for the peer-(N)-entities to negotiate and renegotiate the characteristics of the communication.

5.3.3.3 Connectionless mode

5.3.3.3.1 Connectionless-mode transmission is the transmission of a single unit of data from a source service-access-point to one or more destination service-access-points without establishing a connection. A connectionless-mode service allows an entity to initiate such a transmission by the performance of a single service access.

5.3.3.3.2 In contrast to a connection, an instance of the use of a connectionless-mode service does not have a clearly distinguishable lifetime. In addition,t has the following fundamental characteristics:

a) it requires only a pre-arranged association between the peer-(N)-entities involved which determines the characteristics of the data to be transmitted, and no dynamic agreement is involved in an instance of the use of the service;

b) all the information required to deliver a unit of data – destination address, quality of service selection, options, etc. – is presented to the layer providing the connectionless-mode service, together with the unit of data to be transmitted, in a single service access. The layer providing the connectionless-mode service is not required to relate this access to any other access.

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5.3.3.3.3 As a result of these fundamental characteristics it may also be true that:

a) each unit of data transmitted is routed independently by the layer providing the connectionless-mode service; and

b) copies of a unit of data can be transmitted to a number of destination addresses.

5.3.3.3.4 These characteristics of connectionless-mode transmission do not preclude making available to the service user information on the nature and quality of service which may apply for a single invocation of the service or which may be observed over successive invocations of the service between pairs of (N)-service-access-points or among a set of (N)-service-access-points.

5.3.3.3.5 For each layer, the subclauses of clause 7 identify those items which have relevance to the connectionless-mode service provided by that layer.

5.3.3.3.6 The basic (N)-connectionless-mode service is a service which meets the following conditions:

a) it is not required to exhibit any minimum values of the quality of service measures, in particular the sequence of (N)-service-data-units need not be maintained and;

b) it is not required to exhibit peer flow control.

5.3.3.3.7 Any (N)-connectionless-mode service definition should allow the basic service.

5.3.3.3.8 Since the basic service is not required to maintain the sequence of (N)-service-data-units, there is no requirement for any (N)-layer to provide sequencing functions. However, in real implementations the characteristics of the underlying medium or of real subnetworks may offer a high probability of in-sequence delivery and this may be reflected in the characteristics of the connectionless-mode services offered by higher layers.

5.3.3.3.9 An (N+1)-entity provides no information to the provider of an (N)-connectionless-mode service about the logical relationships between (N)-service-data-units, apart from the source and destination (N)-service-access-point-addresses.

5.3.3.3.10 From the point of view of the (N+1)-entity this means that it is not able to require the (N)-service to apply a particular function to a sequence of (N)-service-data-units sent by it. However, from the point of view of the (N)-layer, this does not imply any constraint on the functions which support the service.

5.3.3.3.11 (N+1)-entities can communicate using an (N)-connectionless-mode service provided that there is a pre-arranged association between them providing knowledge about each other which allows them to do so. This knowledge should allow the locations of the (N+1)-entities to be determined, it should determine the correct interpretation of (N)-ervice-data-units by a receiving (N+1)-entity, and it may define the rates of transfer, rates of response, and the protocol in use between the entities. The knowledge may result from prior agreement between the (N+1)-entities concerning the parameters, formats, and options to be used.

5.3.3.3.12 (N+1)-entities may require prior knowledge of the facilities offered by the service and the quality of service which they can expect to receive from it in order to choose an (N+1)-protocol to be used for communication over an (N)-connectionless-mode service.

5.3.4 The relationship between services provided at adjacent layer boundaries

5.3.4.1 There are no architectural constraints on any vertical combination of an (N)-layer providing one type of (N)-service (connection-mode or connectionless-mode) using the other type of (N–1)-service. In principle the services at the two layer boundaries can be:

a) both connection-mode services;

b) both connectionless-mode services;

c) the (N)-service a connection-mode service and the (N–1)-service a connectionless-mode service;

d) the (N)-service a connectionless-mode service and the (N–1)-service a connection-mode service.

5.3.4.2 In order to allow combinations c) and d) two architectural elements are required:

a) a function to provide an (N)-connection-mode service using an (N–1)-connectionless-mode service; and

b) a function to provide an (N)-connectionless-mode service using an (N–1)-connection-mode service.

These are known as mode conversion functions.

NOTE – Of these functions, function a) requires significant protocol-control-information. For example, there is a need to identify the connection which is constructed, control its state and provide sequencing of service-data-units. Function b) requires little or no additional protocol-control-information, rather, it places constraints on the way in which the connection-mode service is used.

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5.3.5 Application of mode conversion functions

5.3.5.1 Mode conversion functions may be invoked in OSI end systems, or in OSI relay systems (see 6.5). When invoked in OSI relay systems, the mode conversion functions may either:

a) join an (N)-protocol using the (N–1)-connectionless service and an (N)-protocol using the (N–1)-connection-mode service in support of an (N)-connection-mode service; or

b) join an (N)-protocol using the (N–1)-connectionless-mode service and an (N)-protocol using the (N–1)-connection-mode service in support of an (N)-connectionless mode service.

5.3.5.2 The use of mode conversions between (N–1)-services within a layer is not explicitly constrained by the Reference Model but, where several (N–1)-services are connected in tandem, the use of mode conversions would be ordered to minimize the number of mode conversions necessary to arrive at a given composite (N)-service.

5.3.5.3 Where an (N–1)-connectionless-mode service is enhanced to provide a (N)-connection-mode service, a number of (N)-connections may be supported by (N–1)-connectionless-mode transmission between the same (N–1)-service-access-points.

5.3.5.4 Where an (N–1)-connection-mode service is used to provide an (N)-connectionless-mode service, (N)-connectionless-mode transmission between a number of different (N)-service-access-points may be supported by the same (N–1)-connection.

5.4 Identifiers

5.4.1 Definitions

5.4.1.1 **(N)-address:** A name unambiguous within the OSIE which is used to identify a set of (N)-service-access-points which are all located at a boundary between an (N)-subsystem and an (N+1)-subsystem in the same open system.

NOTE – A name is unambiguous within a given scope when it identifies one and only one object within that scope. Unambiguity of a name does not preclude the existence of synonyms.

5.4.1.2 **(N)-service-access-point-address; (N)-SAP-address:** An (N)-address that is used to identify a single (N)-SAP.

5.4.1.3 **(N)-address-mapping:** An (N)-function which provides the mapping between the (N)-addresses and the (N–1)-addresses associated with an (N)-entity.

5.4.1.4 **routing:** A function within a layer which translates the title of an entity or the service-access-point-address to which the entity is attached into a path by which the entity can be reached.

5.4.1.5 **(N)-connection-endpoint-identifier:** An identifier of an (N)-connection-endpoint which can be used to identify the corresponding (N)-connection at an (N)-service-access-point.

5.4.1.6 **(N)-connection-endpoint-suffix:** A part of an (N)-connection-endpoint-identifier which is unique within the scope of an (N)-service-access-point.

5.4.1.7 **multi-connection-endpoint-identifier:** An identifier which specifies the connection-endpoint of a multi-endpoint-connection which should accept the data that is being transferred.

5.4.1.8 **(N)-service-connection-identifier:** An identifier which uniquely specifies an (N)-connection within the environment of the correspondent (N+1)-entities.

5.4.1.9 **(N)-protocol-connection-identifier:** An identifier which uniquely specifies an individual (N)-connection within the environment of the multiplexed (N–1)-connection.

5.4.1.10 **(N)-entity-title:** A name that is used to identify unambiguously an (N)-entity.

5.4.2 Description

5.4.2.1 An (N)-service-access-point-address identifies a particular (N)-service-access-point to which an (N+1)-entity is attached (see Figure 7). When the (N+1)-entity is detached from the (N)-service-access-point, the (N)-SAP-address no longer provides access to the (N+1)-entity. If the (N)-service-access-point is reattached to a different (N+1)-entity, then the (N)-SAP-address identifies the new (N+1)-entity and not the old one.

5.4.2.2 The use of an (N)-SAP-address to identify an (N+1)-entity is the most efficient mechanism if the permanence of attachment between the (N+1)-entity and the (N)-service-access-point can be assured.

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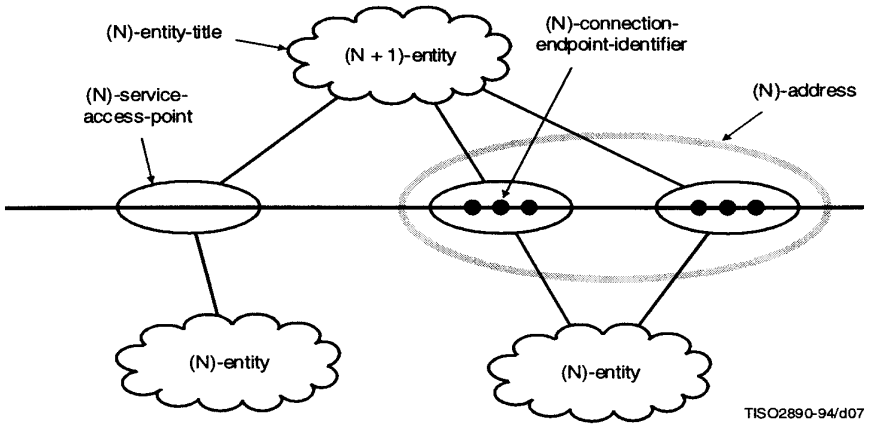


Figure 7 – Entities, service-access-points and identifiers

5.4.2.3 Interpretation of the correspondence between the (N)-addresses served by an (N)-entity and the (N–1)-addresses used for accessing (N–1)-services is performed by an (N)-address-mapping function.

5.4.2.4 The structure of an (N)-address is known by the (N)-entity which is attached to the identified (N)-service-access-point. However, the (N+1)-entity does not know this structure.

5.4.2.5 If an (N+1)-entity has two or more (N)-service-access-points with either the same (N)-entity or different (N)-entities, the (N)-entities have no knowledge of this fact. Each (N)-service-access-point is considered to identify a different (N+1)-entity from the perspective of the (N)-entities.

5.4.2.6 A routing function translates the (N)-address of an (N+1)-entity into a path or route by which the (N+1)-entity may be reached.

5.4.2.7 An (N+1)-entity may establish an (N)-connection with another (N+1)-entity by using an (N)-service. When an (N+1)-entity establishes an (N)-connection with another (N+1)-entity, each (N+1)-entity is given an (N)-connection-endpoint-identifier by its supporting (N)-entity. The (N+1)-entity can then distinguish the new connection from all other (N)-connections accessible at the (N)-service-access-point it is using. This (N)-connection-endpoint-identifier is unique within the scope of the (N+1)-entity which will use the (N)-connection.

5.4.2.8 The (N)-connection-endpoint-identifier consists of two parts:

a) the (N)-SAP-address of the (N)-service-access-point which will be used in conjuction with the (N)-connection; and

b) an (N)-connection-endpoint-suffix which is unique within the scope of the (N)-service-access-point.

5.4.2.9 A multi-endpoint-connection requires multi-connection-endpoint-identifiers. Each such identifier is used to specify which connection-endpoint should accept the data which is being transferred. A multi-connection-endpoint-identifier is unique within the scope of the connection within which it is used.

5.4.2.10 The (N)-layer may provide to the (N+1)-entities an (N)-service-connection-identifier which uniquely specifies the (N)-connection within the environment of the correspondent (N+1)-entities.

5.5 Properties of service-access-points

5.5.1 An (N+1)-entity requests (N)-service via an (N)-service-access-point which permits the (N+1)-entity to interact with an (N)-entity.

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5.5.2 Both the (N)- and (N+1)-entities attached to an (N)-service-access-point are in the same system.

5.5.3 An (N+1)-entity may concurrently be attached to one or more (N)-service-access-points attached to the same or different (N)-entities.

5.5.4 An (N)-entity may concurrently be attached to one or more (N+1)-entities through (N)-service-access-points.

5.5.5 An (N)-service-access-point is attached to only one (N)-entity and to only one (N+1)-entity at a time.

5.5.6 An (N)-service-access-point may be detached from an (N+1)-entity and reattached to the same or another (N+1)-entity.

5.5.7 An (N)-service-access-point may be detached from an (N)-entity and reattached to the same or another (N)-entity.

5.5.8 An (N)-service-access-point is located by means of its (N)-SAP-address. An (N)-SAP-address is used by an (N+1)-entity to request an instance of communication.

5.5.9 An (N)-service-access-point may support:

a) (N)-connection-mode service only;

b) (N)-connectionless-mode service only;

c) (N)-connection-mode services and (N)-connectionless-mode services concurrently.

5.5.10 A single (N+1)-entity may concurrently be using several (N)-connections and an (N)-connectionless-mode service through one or more (N)-service-access-points to which it is attached.

5.5.11 (N+1)-entities distinguish between instances of the (N)-connectionless-mode services and the (N)-connection-mode services offered concurrently through the same (N)-service-access-point by the uniqueness of the interactions prescribed for these services.

5.6 Data-units

5.6.1 Definitions

5.6.1.1 (N)-protocol-control information: Information exchanged between (N)-entities to co-ordinate their joint operation.

5.6.1.2 (N)-user-data: The data transferred between (N)-entities on behalf of the (N+1)-entities for whom the (N)-entities are providing services.

5.6.1.3 (N)-protocol-data-unit: A unit of data specified in an (N)-protocol and consisting of (N)-protocol-control-information and possibly (N)-user-data.

5.6.1.4 (N)-service-data-unit: An amount of information whose identity is preserved when transferred between peer-(N+1)-entities and which is not interpreted by the supporting (N)-entities.

5.6.1.5 expedited (N)-service-data-unit. (N)-expedited-data-unit: A small (N)-service-data-unit whose transfer is expedited. The (N)-layer ensures that an expedited-data-unit will not be delivered after any subsequent service-data-unit or expedited unit sent on that connection.

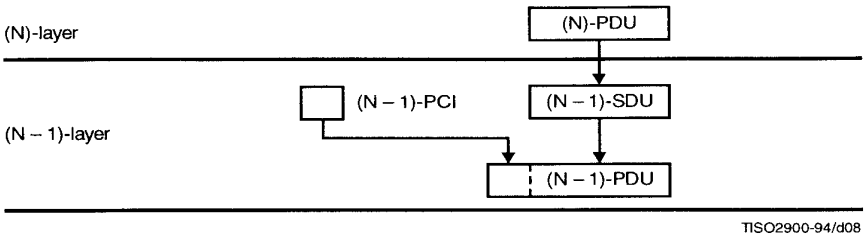
5.6.2 Description

5.6.2.1 Information is transferred in various types of data-units between peer-(N)-entities. The data-units are defined in 5.6 and the relationships among them are illustrated in Figures 8 and 9.

	Control	Data	Combined
(N)-(N)-peer-entities	(N)-protocol-control-information	(N)-user-data	(N)-protocol-data-unit

Figure 8 – Relationships among data-units

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PCI Protocol-control-information
PDU Protocol-data-unit
SDU Service-data-unit

NOTES

1 This figure assumes that neither segmenting nor blocking of (N)-service-data-units is performed (see 5.8.1.9 and 5.8.1.11).

2 This figure does not imply any positional relationship between protocol-control-information and user-data in protocol-data-unit.

3 An (N)-protocol-data-unit may be mapped one-to-one into an (N – 1)-service-data-unit, but other relationships are possible.

Figure 9 – An illustration of mapping between data-units in adjacent layers

5.6.2.2 Except for the relationships defined in Figures 8 and 9, there is no overall architectural limit to the size of data-units. There may be other size limitations at specific layers.

5.6.2.3 Data may be held within a connection until a complete service-data-unit is put into the connection.

5.7 The nature of the (N)-service

5.7.1 An (N)-service does not necessarily place bounds on the size of (N)-SDUs. The specification of the (N)-protocol, however, may place specific bounds on the size of (N)-PDUs. Blocking, segmenting, and concatenation are used to reconcile differences in the sizes of SDUs and corresponding PDUs.

5.8 Elements of layer operation

5.8.1 Definitions

5.8.1.1 (N)-protocol-identifier: An identifer used between correspondent (N)-entities to select a specific (N)-protocol.

5.8.1.2 centralized multi-endpoint-connection: A multi-endpoint-connection where data sent by the entity associated with the central connection-endpoint is received by all other entities, while data sent by one of the other entities is only received by the central entity.

5.8.1.3 decentralized multi-endpoint-connection: A multi-endpoint-connection where data sent by an entity associated with a connection-endpoint is received by all other entities.

5.8.1.4 multiplexing: A function performed by an (N)-entity in which one (N–1)-connection is used to support more than one (N)-connection.

NOTE – The term multiplexing is also used in a more restricted sense to refer to the function performed by the sending (N)-entity while the term demultiplexing is used to refer to the function performed by the receiving (N)-entity.

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5.8.1.5 demultiplexing: A function performed by an (N)-entity which identifies (N)-protocol-data-units for more than one (N)-connection within an (N–1)-connection. It is the reverse function of the multiplexing function performed by the (N)-entity sending the (N–1)-service-data-units.

5.8.1.6 splitting: A function within the (N)-layer by which more than one (N–1)-connection is used to support one (N)-connection.

NOTE – The term splitting is also used in a more restrictive sense to refer to the function performed by the sending (N)-entity while the term recombining is used to refer to the function performed by the receiving (N)-entity.

5.8.1.7 recombining: The function performed by an (N)-entity which identifies (N)-protocol-data-units for a single (N)-connection in (N–1)-service-data-units received on more than one (N–1)-connection. It is the reverse function of the splitting function performed by the (N)-entity sending the (N–1)-service-data-units.

5.8.1.8 flow control: A function which controls the flow of data within a layer or between adjacent layers.

5.8.1.9 segmenting: A function performed by an (N)-entity to map one (N)-service-data-unit into multiple (N)-protocol-data-units.

5.8.1.10 reassembling: A function performed by an (N)-entity to map multiple (N)-protocol-data-units into one (N)-service-data-unit. It is the reverse function of segmenting.

5.8.1.11 blocking: A function performed by an (N)-entity to map multiple (N)-service-data-units into one (N)-protocol-data-unit.

5.8.1.12 deblocking: A function performed by an (N)-entity to identify multiple (N)-service-data-units which are contained in one (N)-protocol-data-unit. It is the reverse function of blocking.

5.8.1.13 concatenation: A function performed by an (N)-entity to map multiple (N)-protocol-data-units into one (N–1)-service-data-unit.

NOTE – Blocking and concatenation though similar (they both permit grouping of data-units) may serve different purposes. For instance, concatenation permits the (N)-layer to group one or several acknowledgement (N)-PDUs with one (or several) (N)-PDUs containing user-data. This would not be possible with the blocking function only. Note also that the two functions may be combined so that the (N)-layer performs blocking and concatenation.

5.8.1.14 separation: A function performed by an (N)-entity to identify multiple (N)-protocol-data-units which are contained in one (N–1)-service-data-unit. It is the reverse function of concatenation.

5.8.1.15 sequencing: A function performed by the (N)-layer to preserve the order of (N)-service-data-units that were submitted to the (N)-layer.

5.8.1.16 acknowledgement: A function of the (N)-layer which allows a receiving (N)-entity to inform a sending (N)-entity of the receipt of an (N)-protocol-data-unit.

5.8.1.17 reset: A function which sets the corresponding (N)-entities to a predefined state with a possible loss or duplication of data.

5.8.1.18 (N)-protocol-version-identifier: An identifier conveyed between correspondent (N)-entities which allows the selection of the version of an (N)-protocol.

NOTE – The definition of a new (N)-protocol-version-identifier presupposes a minimal common knowledge of the (N)-protocol identified by the preceding (N)-protocol-version-identifier. When such a minimal common knowledge cannot be achieved, the (N)-protocols are considered to be independent and different.

5.8.2 Protocol selection and identification

5.8.2.1 Protocol identification is the process of determining the type of protocol being used.

5.8.2.2 One or more (N)-protocols may be defined for the (N)-layer. An (N)-entity may employ one or more (N)-protocols.

5.8.2.3 Meaningful communication between (N)-entities requires the agreed selection of one (N)-protocol.

5.8.2.4 (N)-protocol-identifiers name the specific protocols defined. An (N+1)-protocol-identifier cannot be part of (N)-PCI. Thus, an (N)-service uses (N)-addresses to identify an (N+1)-protocol, as described in Rec. X.650 | ISO 7498-3.

5.8.2.5 Since not all protocols (either OSI or non-OSI) can be assumed to carry an (N)-protocol-identifier, an (N)-protocol-identifier cannot be used to distinguish OSI and non-OSI protocols. The proper mechanism to use in these situations is an (N)-address.

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5.8.3 Protocol version selection and identification

5.8.3.1 Protocol version identification

5.8.3.1.1 Protocol version identification is a mechanism to identify the level of a particular protocol being used. The identification of the protocol version presupposes that the protocol itself has been identified either implicitly or by use of approved mechanisms.

5.8.3.1.2 It may be convenient, in many cases, to recognize a sub-version id to be carried in (N)-PCI along with the (N)-protocol-version-id. This allows keeping track of minor evolutions of a given protocol version (e.g. in order to determine the degree of integration of defect reports, etc.). The decision of whether or not to introduce such a sub-version id is of the responsibility of specific (N)-layer standards. However, only the (N)-protocol-version-id, regardless of any additional subversion id, is taken into account in order to determine whether or not communication is possible between peer-(N)-entities.

5.8.3.2 The need for a new protocol version

5.8.3.2.1 The need for a new protocol version arises from changes made in the protocol. These changes can be:

1) addition of new functions (i.e. not defined in the existing protocol specifications);
2) deletion of existing functions (i.e. which were defined in the existing protocol specifications);
3) modification of existing functions; or
4) substitution of an alternate way to provide existing functions.

5.8.3.2.2 Changes made in a protocol will not always imply the need for a new protocol version (or for a new protocol). A new protocol version (or new protocol) becomes necessary when these changes lead to a significant functional modification which cannot be compatibly negotiated using the existing protocol specifications so that a real open system utilizing the newly specified protocol functions would not be able to communicate with a real open system utilizing the old specifications.

5.8.3.2.3 In such cases, if the two sets of protocol functions share at least a common understanding of the protocol version identification mechanisms (e.g. conveying, encoding, negotiating protocol version identifiers), they are considered to be two different versions of the same protocol, otherwise they are considered to be two different protocols.

NOTES

1 It is important to note that significant functional modifications are not always coupled to changes to protocol elements exchanged between pair entities (e.g. modification of the behavior of an (N)-entity due to the introduction of transparent services).

2 It should be noted that new protocol versions are not directly related to the administrative process of revising existing standards. Such a process may or may not lead to a new protocol version depending on the degree of modification which has taken place.

5.8.3.3 Negotiation mechanisms

5.8.3.3.1 The negotiation of protocol version can only occur in connection-mode communication. An (N)-protocol-version-id field should be present in PDUs relevant to connection establishment. A mechanism for handling protocol version identification is to determine, by means of the (N)-protocol-version-id, which version should be invoked on a specific connection between the calling and called (N)-entities.

5.8.3.3.2 A calling (N)-entity sends information of all supported versions to a called (N)-entity. The called (N)-entity examines whether or not there are any supported versions common to the calling and called (N)-entities. If there is more than one common version, the latest common version is selected. If there is no common version, the connection establishment request is refused.

5.8.3.3.3 The sub-version id, when present, is not used in the negotiation mechanisms.

5.8.3.3.4 In connectionless-mode protocols, no negotiation mechanism is provided. Identification of the protocol version is either implicit (e.g. a priori knowledge) or explicitly conveyed in the PDUs.

5.8.4 Properties of connectionless-mode transmission

5.8.4.1 All the information required by an (N)-connectionless-mode service to deliver an (N)-service-data-unit (destination address, quality of service required, options, etc.) is presented to it with the (N)-service-data-unit in a single logical service access by the sending (N+1)-entity.

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5.8.4.2 All information related to an (N)-service-data-unit, together with the (N)-service-data-unit itself, is received from the (N)-service in a single logical service access by the receiving (N+1)-entity.

5.8.4.3 To provide the (N)-connectionless-mode service, the (N)-layer performs functions as described in 5.3.3.3. These functions are supported by (N)-protocols.

5.8.4.4 If an (N)-service-data-unit cannot be accepted by an (N+1)-entity at the time of its arrival at an (N)-service-access-point, the (N+1)-entity may apply service boundary flow control (see 5.8.8.4). This may result in the discarding of the (N)-service-data-unit by the (N)-service provider or, where flow control is provided, in the exercise of service boundary flow control at the sending (N)-service-access-point by the (N)-service provider.

5.8.4.5 An (N)-connectionless-mode service may allow the transmission of copies of an (N)-service-data-unit to a number of destination (N)-service-access-points. (N)-service-data-units transmitted from a number of source (N)-service-access-points can be received at one destination (N)-service-access point. The (N)-layer does not assume any logical relationship between these (N)-service-data-units.

5.8.4.6 No (N)-protocol-control-information is exchanged between (N)-entities concerning the mutual willingness of the (N+1)-entities to exchange data using an (N)-connectionless-mode service.

NOTES

1 The specific interface mechanism employed by a particular implementation of a connectionless-mode service may involve more than one interface exchange to accomplish the single logical service access necessary to initiate a connectionless-mode transmission. However, this is a local implementation detail.

2 The transmission of each (N)-service-data-unit by an (N)-connectionless-mode service should be entirely self-contained. All the addressing and other information required by the (N)-layer to deliver the (N)-service-data-unit to its destination should be included in the service access for each transmission.

3 It is a basic characteristic of connectionless-mode service that no negotiation of the parameters for a transmission takes place at the time the service is accessed and no dynamic association is set up between the parties involved. However, considerable freedom of choice can be preserved by allowing most parameter values and options (such as transfer rate, acceptable error rate, etc.) to be specified at the time the service is accessed. In a given implementation, if the local (N)-subsystem determines immediately (from information available to it locally) that the requested transmission cannot be performed under the conditions specified, it may abort the transmission, returning an implementation specific error message. If the same determination is made later, after the service access has been completed, the transmission is abandoned, since the (N)-layer is assumed not to have the information necessary to take any other action.

5.8.5 Properties of connection-mode transmission

5.8.5.1 An (N)-connection is an association established for communication between two or more (N+1)-entities, identified by their (N)-addresses. An (N)-connection is offered as a service by the (N)-layer, so that information may be exchanged between the (N+1)-entities.

5.8.5.2 An (N+1)-entity may have, simultaneously, one or more (N)-connections with other (N+1)-entities, with any given (N+1)-entity, and with itself.

5.8.5.3 An (N)-connection is established by referencing, either explicitly or implicity, an (N)-address for the source (N+1)-entity and an (N)-address for each of one or more destination (N+1)-entities.

NOTE – The specific interface mechanism employed by a particular implementation of a connection-mode service may involve more than one interface exchange to accomplish the single logical service access necessary to initiate a connection-mode transmission. However, this is a local implementation detail.

5.8.5.4 The source (N)-address and one or more of the destination (N)-addresses may be the same. One or more of the destination (N)-addresses may be the same while the source (N)-address is different. All may be different.

5.8.5.5 One (N)-connection-endpoint is constructed for each (N)-SAP-address referenced explicitly or implicitly when an (N)-connection is established.

5.8.5.6 An (N+1)-entity accesses an (N)-connection via an (N)-service-access-point.

5.8.5.7 An (N)-connection has two or more (N)-connection-endpoints.

5.8.5.8 An (N)-connection-endpoint is not shared by (N+1)-entities or (N)-connections.

5.8.5.9 An (N)-connection-endpoint relates three elements:

a) an (N+1)-entity;

b) an (N)-entity; and

c) an (N)-connection.

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5.8.5.10 The (N)-entity and the (N+1)-entity related by an (N)-connection-endpoint are those implied by the (N)-SAP-address referenced when the (N)-connection is established.

5.8.5.11 An (N)-connection-endpoint has an identifier, called an (N)-connection-endpoint-identifier, which is unique within the scope of the (N+1)-entity which is bound to the (N)-connection-endpoint.

5.8.5.12 An (N)-connection-endpoint-identifier is not the same as an (N)-SAP-address.

5.8.5.13 An (N+1)-entity references an (N)-connection, using its (N)-connection-endpoint-identifier.

5.8.5.14 Multi-endpoint-connections are connections which have three or more connection-endpoints. Two types of multi-endpoint-connection are defined:[3)]

a) centralized; and

b) decentralized.

5.8.5.15 A centralized multi-endpoint-connection has a central connection-endpoint. Data sent by the entity associated with the central connection-endpoint is received by the entities associated with all other connection-endpoints. The data sent by an entity associated with any other connection-endpoint is received by the entity associated with the central connection-endpoint.

5.8.5.16 On a decentralized multi-endpoint-connection, data sent by an (N)-entity associated with any connection-endpoint is received by the (N)-entities associated with all of the other connection-endpoints.

5.8.6 Connection establishment and release

5.8.6.1 Introduction

5.8.6.1.1 All (N)-connections require establishment and release procedures. These procedures

- may be designed to send (N)-PCI on the same (N)-connection as (N)-user-data (sometimes called in-band);
- may be designed to send (N)-PCI on a different (N)-connection than (N)-user-data (sometimes called out-of-band); or
- may be a priori procedures.

A priori procedures are not the concern of OSI. These procedures may or may not be standardized. In all of these cases, the basic properties of the procedures are the same. Equivalent information is exchanged to initialize and synchronize the state of the correspondent (N)-entities. OSI is only concerned with in-band and out-of-band establishment and release procedures which are standardized.

Table 1 – Functions used in Modes of Communication

Reference (Subclause)	Function	Connection	Connectionless
5.8.6	Conn Estab. & Rel	x	
5.8.6.4	Suspend	x	
5.8.6.5	Resume	x	
5.8.7	Muxing & Splitting	x	x
5.8.8.1	Normal Data Transfert	x	x
5.8.8.2	during Establishment	x	
5.8.8.3	Flow Control	x	x
5.8.8.4	Expedited	x	
5.8.8.5	Segmenting	x	x
	Blocking	x	
	Concatenation	x	x
5.8.8.6	Sequencing	x	x
5.8.9.1	Acknowledgement	x	x
5.8.9.2	Error Detect & Notif	x	x
5.8.9.3	Reset	x	
5.9	Routing	x	x
5.10	Quality of Service	xx	x

3) Other typed of multi-endpoint-connections are for further study.

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5.8.6.1.2 OSI protocols, operating independently of a given set of instances of communication, may be employed to control the resources that are required to support those instances of communications. These protocols, which are often called "out-of-band", can be used, for example, in support of the establishment of (N)-connections. Information needed for the establishment of an (N)-connection may be conveyed, not only through the direct (normally called "in-band") (N)-protocol, but also as part of a different (N)-layer protocol, common to many instances of communications.

5.8.6.1.3 Non-standard procedures can be allowed in a compatible manner without affecting the operation of the (N)-protocol or (N+1)-protocol. These non-standard procedures should not affect addressing, quality of service, service primitives, OSI management, etc.

5.8.6.1.4 Some (N)-protocols may provide for the combining of connection establishment and connection release protocol exchanges.

5.8.6.2 Connection establishment

5.8.6.2.1 The establishment of an (N)-connection by peer-(N)-entities of an (N)-layer requires the following:

a) the availability of an (N–1)-service between the supporting (N)-entities; and

b) both (N)-entities be in a state in which they can execute the connection establishment protocol exchange.

5.8.6.2.2 If it is not already available, an (N–1)-service has to be established by peer-(N–1)-entities of the (N–1)-layer. This requires, for the (N–1)-layer, the same conditions as described above for the (N)-layer.

5.8.6.2.3 The same consideration applies downwards until either an available lower layer service or the physical medium for OSI is encountered.

5.8.6.2.4 Depending upon the characteristics of the (N–1)-service and of the establishment protocol exchange, the establishment of an (N)-connection may or may not be done in conjunction with the establishment of the (N–1-connection.

5.8.6.2.5 The characteristics of the (N)-service with regard to the establishment of the (N)-connection vary depending upon whether or not (N)-user-data can be transferred by the connection establishment protocol exchange for each direction of the (N)-connection.

5.8.6.2.6 Where (N)-user-data is transferred by the (N)-connection establishment protocol exchange, the (N+1)-protocol may take advantage of this to allow an (N+1)-connection to be established in conjunction with the establishment of the (N)-connection. This is termed "embedding of connection establishment". If embedding at all layers were to be permitted, then the length of the user-data parameter in a connection establishment PDU may have to be indefinite.

5.8.6.2.7 At certain layers the complexity involved in providing arbitrarily long user data fields in connection establishment primitives at every layer may outweigh any savings that could be accomplished by embedding.

5.8.6.2.8 Embedding between adjacent layers where there are multiplexing, re-use, or quality of service enhancement functions causes complexity and redundancy of mechanism. Such additional complexity and redundancy do not necessarily cancel out all of the potential advantages of embedding. It is the responsibility of a layer to decide when protocol elements should be passed in the connection request or in the first data request, provided that adequate protocols are defined which allow such a selection.

5.8.6.2.9 If embedding is used, failure of a connection establishment will result in failure of the embedded connection establishments.

5.8.6.3 Connection Release

5.8.6.3.1 The release of an (N)-connection is normally initiated by one of the (N+1)-entities associated in it.

5.8.6.3.2 The release of an (N)-connection may also be initiated by one of the (N)-entities supporting it as a result of an exception condition occurring in the (N)-layer or the layers below.

5.8.6.3.3 Depending upon the conditions, release of an (N)-connection may result in the discarding of (N)-user-data.

5.8.6.3.4 The orderly release of an (N)-connection requires either the availability of an (N–1)-connection, or a common reference to time (for example, time of failure of the (N–1)-connection and common time-out). In addition, it requires that both (N)-entities are in a state in which they can execute the connection release protocol exchange. It is important to note, however, that the release of an (N–1)-connection does not necessarily cause the release of the (N)-connection(s) which were using it; the (N–1)-connection can be re-established, or another (N–1)-connection substituted.

NOTE – The common reference to time refers to the expiration of time with respect to, or relative to an instance of service.

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5.8.6.3.5 The characteristics of the (N)-service with regard to the release of an (N)-connection can be of two kinds:

a) (N)-connections are either released immediately when the release protocol is initiated [(N)-user-data not yet delivered may be discarded]; or

b) release is delayed until all (N)-user-data sent previous to the initiation of the release protocol exchange has been delivered (i.e. delivery confirmation has been received).

5.8.6.3.6 (N)-user-data may be transferred by the connection release protocol exchange.

5.8.6.4 The Suspend function

Suspend is an OSI function provided by the (N)-layer in which a (N–1)-connection can be terminated while the (N)-connection is preserved. A Suspend function in an (N)-layer may be invoked at the explicit request of an upper layer when an upper layer entity has knowledge of future activity that indicate that releasing the (N–1)-connection would be advantageous, or it may be invoked spontaneously within the operation of the (N)-layer based on the occurrence of some condition (e.g. some period of time with no data transferred) that makes it advantageous to release the (N–1)-connection.

5.8.6.5 The Resume function

Normal operation will be resumed as soon as one party or the other is required to communicate across the suspended (N–1)-connection. To resume such a connection, the (N)-layer will have to re-establish the (N–1)-connection.

5.8.7 Multiplexing and splitting

5.8.7.1 Within the (N)-layer, (N)-connections are mapped onto (N–1)-connections. The mapping may be one of three kinds:

a) one-to-one;

b) many (N)-connections to one (N–1)-connection (multiplexing); and

c) one (N)-connection to many (N–1)-connections (splitting).

5.8.7.2 Multiplexing may be needed in order to:

a) make more efficient or more economic use of the (N–1)-service; and

b) provide several (N)-connections in an environment where only a single (N–1)-connection exists.

5.8.7.3 Splitting may be needed in order to:

a) improve reliability where more than one (N–1)-connection is available;

b) provide the required grade of performance, through the utilization of multiple (N–1)-connections; and

c) obtain cost benefits by the utilization of multiple low cost (N–1)-connections each with less than the required grade of performance.

5.8.7.4 Multiplexing and splitting each involve a number of associated functions which may not be needed for one-to-one connection mapping.

5.8.7.5 The functions associated with multiplexing are:

a) identification of the (N)-connection for each (N)-protocol-data-unit transferred over the (N–1)-connection, in order to ensure that (N)-user-data from the various multiplexed (N)-connections are not mixed. This identification is distinct from that of the (N)-connection-endpoint-identifiers and is called an (N)-protocol-connection-identifier;

b) flow control on each (N)-connection in order to share the capacity of the (N–1)-connection (see 5.8.8.3); and

c) scheduling the next (N)-connection to be serviced over the (N–1)-connection when more than one (N)-connection is prepared to send data.

5.8.7.6 The functions associated with splitting are:

a) scheduling the utilization of multiple (N–1)-connections used in splitting a single (N)-connection; and

b) resequencing of (N)-protocol-data-units associated with an (N)-connection since they may arrive out of sequence even when each (N–1)-connection guarantees sequence of delivery (see 5.8.8.6).

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5.8.8 Transfer of data

5.8.8.1 Normal data transfer

5.8.8.1.1 Control information and user data are transferred between (N)-entities in (N)-protocol-data-units. An (N)-protocol-data-unit is a unit of data specified in an (N)-protocol and contains (N)-protocol-control-information and possibly (N)-user-data.

5.8.8.1.2 (N)-protocol-control-information is transferred between (N)-entities using an (N–1)-service. (N)-protocol-control-information is any information that supports the joint operation of (N)-entities. (N)-user-data is passed transparently between (N)-entities using an (N–1)-service.

5.8.8.1.3 An (N)-protocol-data-unit has a finite size, which may be limited by the (N–1)-protocol-data-unit size and by the capabilities of the (N)-protocol. (N)-protocol-data-units are mapped into (N–1)-service-data-units. The interpretation of an (N)-protocol-data-unit is defined by the (N)-protocol in effect for the (N)-service.

5.8.8.1.4 An (N)-service-data-unit is transferred between an (N+1)-entity and an (N)-entity, through an (N)-service-access-point. Each (N)-service-data-unit is transferred as (N)-user-data in one or more (N)-protocol-data-units.

5.8.8.1.5 The exchange of data under the rules of an (N)-protocol can only occur if an instance of the (N–1)-service exists. If an instance of the (N–1)-service does not exist, it shall be established before an exchange of data can occur (see 5.8.6).

5.8.8.1.6 The quality of service agreed when the connection was established is related to the flow of service-data-units across service-access-points.

5.8.8.1.7 Even when blocking takes place it is always within the quality of service agreed when the connection was established. There is no case where data will be delayed indefinitely.

5.8.8.2 Data transfer during connection establishment and release

5.8.8.2.1 (N)-user-data may be transferred in the (N)-connection establishment protocol exchange and in the (N)-connection release protocol exchange.

5.8.8.2.2 The connection release protocol exchange may be combined with the connection establishment protocol exchange (see 5.8.6) to provide a means for the delivery of a single unit of (N)-user-data between correspondent (N+1)-entities with a confirmation of receipt.

5.8.8.3 Flow control

5.8.8.3.1 If flow control functions are provided in connectionless-mode, they can operate only on protocol-data-units and service-data-units.

5.8.8.3.2 Two types of flow control are identified:

a) peer flow control which regulates the rate at which (N)-protocol-data-units are sent between (N)-entities supporting either (N)-connectionless-mode or (N)-connection-mode transmission. Peer flow control requires protocol definitions and is based on protocol-data-unit size; and

b) service boundary flow control, which regulates the rate at which (N)-service-data-units are passed between an (N+1)-entity and an (N)-entity that supports either an (N)-connectionless-mode or (N)-connection-mode service. Service boundary flow control is based on (N)-service-data-unit size.

5.8.8.3.3 In connectionless-mode transmission, peer flow control may operate on (N)-PDUs within an (N)-SDU, but not across (N)-SDU boundaries.

NOTE – It may happen however that peer flow control actually results in de facto action across (N)-SDU boundaries. Such is the case when a sublayer using a connectionless-mode protocol operates over a sublayer operating a connection-mode protocol. Successive (N)-SDUs may be carried in connectionless PDUs which are themselves carried in the PDUs of the connection-mode protocol. Any peer flow control operating on these PDUs thus results in an action across the (N)-SDU boundaries.

5.8.8.3.4 Multiplexing in a layer may require a peer flow control function for individual flows (see 5.8.7.5).

5.8.8.3.5 Peer flow control functions require flow control information to be included in the (N)-protocol-control-information of an (N)-protocol-data-unit.

5.8.8.3.6 If the size of service-data-units exceeds the maximum size of the (N)-user-data portion of an (N)-protocol-data-unit, then first segmentation shall be performed on the (N)-service-data-unit to make it fit within the (N)-protocol-data-units. Peer flow control can then be applied on the (N)-protocol-data-units.

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5.8.8.4 Expedited transfer of data

5.8.8.4.1 An expedited-data-unit is a service-data-unit which is transferred and/or processed with priority over normal service-data-units. An expedited data transfer service may be used for signalling and interrupt purposes. Expedited data is only provided in connection-mode transmission.

5.8.8.4.2 Expedited data flow is independent of the states and operation of the normal data flow, although the data sent on the two flows may be logically related. Conceptually, a connection that supports expedited flow can be viewed as having two subchannels, one for normal data, the other for expedited data. Data sent on the expedited channel is assumed to be given priority over normal data.

5.8.8.4.3 The transfer guarantees that an expedited-data-unit will not be delivered after any subsequent normal service-data-unit or expedited-data-unit sent on the connection.

5.8.8.4.4 Because the expedited flow is assumed to be used to transfer small amounts of data infrequently, simplified flow control mechanisms may be used on this data flow.

5.8.8.4.5 An expedited (N)-service-data-unit is intended to be processed by the receiving (N+1)-entity with priority over normal (N)-service-data-units.

5.8.8.4.6 An expedited (N)-SDU is associated with a specific (N)-connection. Expedited data is defined relative to the normal data flow of the associated (N)-connection. It is not necessarily expedited with respect to other (N)-connections or the connections in higher or lower layers. Expedited data at the (N)-layer will not necessarily be expedited at a lower layer.

5.8.8.4.7 Expedited data is not destructive and should not be confused with reset. The receiving entity may decide on some response, such as to abort output, which is destructive, but that is a separate step. Further, expedited data is not provided as a method for providing two streams of traffic at different priority levels. Expedited data is intended for use in exceptional circumstances; not as part of routine transfer of data.

5.8.8.4.8 Expedited data transmission as defined here does not occur with connectionless-mode data transmission. Although a similar effect may be achieved by requesting different quality of service parameters, such as lower delay time or higher "priority", it is impossible to guarantee delivery before "any subsequent normal SDU" by that means.

5.8.8.4.9 The constraints imposed by the above clauses are that the expedited-data-units:

1) have a limited size; and

2) are subject to separate flow control mechanisms in each (N)-layer.

5.8.8.4.10 In general, this latter constraint means that some small number of expedited data units (usually one) may be outstanding at a time.

5.8.8.4.11 The consequence of these constraints is that, one should use caution in allowing for mapping an (N)-layer expedited data service to an (N–1) layer expedited data service:

1) The size limitation can require dependency between layers to match sizes or might require segmenting and blocking of expedited (N)-SDUs at the (N–1) layer.

   NOTE – If the sender provides for mapping of an expedited service through several layers, e.g. Application to Session Layers, and there are uniform size restrictions so that there is no segmenting, then the receiving station will operate properly supporting the expedited service on a layer-by-layer basis whether or not it can provide the same expedited service mapping when it is the sender. Therefore, the size limitations may not have to be formally called out in a standard.

2) There are likely to be problems in managing the use of the (N–1)-expedited-service if that service is used by the (N)-layer in the operation of the (N)-protocol and in providing the (N)-expedited-service.

3) Such a mapping should not be done if the (N)-layer performs multiplexing onto (N–1)-connections. Flow control on expedited at the (N–1) layer can interfere and inhibit expedited on the (N)-connections multiplexed on the (N–1)-connection.

5.8.8.4.12 In consequence it is preferred that the expedited (N)-SDU be handled entirely by (N)-functions and only rely on the basic (N–1)-data transfer facility, not on special services of the (N–1)-layer, such as (N–1) expedited-service. Where the (N)-protocol makes no use of the (N–1)-expedited-service, an exception may occur. In this case, the (N)-expedited-service-data-unit may then be passed directly through to the (N–1)-expedited-service.

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5.8.8.4.13 Although it may be viable in certain very well constrained cases, as noted above, to map an expedited (N)-SDU to an expedited (N–1)-SDU, this mapping is to be avoided if possible. In some cases, layers may be required to provide more elaborate expedited service such as secure expedited or more flexible flow control, etc. In these cases, more complicated mechanisms will be required to provide the services, such as a separate (N–1)-connection. Such elaboration or mechanisms for efficiency lead to the recommendation to avoid the (N)-expedited to (N–1)-expedited mapping.

5.8.8.4.14 It should be noted that the expedited service does not guarantee that lower layer flow control mechanisms can be bypassed. The expedited message may be permanently blocked.

5.8.8.5 Segmenting, blocking, and concatenation

5.8.8.5.1 Data-units in the various layers are not necessarily of compatible size. It may be necessary to perform segmenting, i.e. to map an (N)-service-data-unit into more than one (N)-protocol-data-unit. Similarly, separation may occur when (N)-protocol-data-units are mapped into a (N–1)-service-data-unit. Since it is necessary to preserve the identity of (N)-service-data-units on an (N)-connection, functions shall be available to identify the segments of an (N)-service-data-unit and to allow the correspondent (N)-entities to reassemble the (N)-service-data-unit.

5.8.8.5.2 Segmenting may require that information be included in an (N)-protocol-control-information of an (N)-protocol-data-unit. Within a layer, (N)-protocol-control-information is added to the (N)-service-data-unit to form an (N)-protocol-data-unit when no segmenting or blocking is performed [see Figure 10 a)]. If segmenting is performed, an (N)-service-data-unit is mapped into several (N)-protocol-data-units with added (N)-protocol-control-information [see Figure 10 b)].

5.8.8.5.3 Conversely, it may be necessary to perform blocking. Blocking is the mechanism where several (N)-service-data-units with added (N)-protocol-control-information form an (N)-protocol-data-unit [see Figure 10 c)].

5.8.8.5.4 The Reference Model also permits concatenation where several (N)-protocol-data-units are concatenated into a single (N–1)-service-data-unit [see Figure 10 d)].

5.8.8.5.5 Segmenting and concatenation functions may occur in connectionless-mode transmission. Blocking and deblocking functions are not allowed in connectionless-mode transmission.

5.8.8.6 Sequencing

5.8.8.6.1 The (N–1)-services provided by the (N–1)-layer of the OSI architecture may not guarantee delivery of (N–1)-service-data-units in the same order as they were submitted by the (N)-layer. In such case, if the (N)-layer needs to preserve the order of (N–1)-service-data-units transferred through the (N–1)-layer sequencing mechanisms shall be present in the (N)-layer. Sequencing may require additional (N)-protocol-control-information.

5.8.8.6.2 In connectionless-mode transmission, sequencing occurs only indirectly when reassembly is applied to an (N)-SDU.

5.8.9 Error functions

5.8.9.1 Acknowledgement

5.8.9.1.1 An acknowledgement function may be used by (N)-entities using an (N)-protocol to obtain a higher probability of detecting protocol-data-unit loss than is provided by the (N–1)-layer. Each (N)-protocol-data-unit transferred between correspondent (N)-entities is made uniquely identifiable, so that the receiver can inform the sender of the receipt of the (N)-protocol-data-unit. An acknowledgement function is also able to infer the non-receipt of (N)-protocol-data-units and the need to take appropriate remedial action.

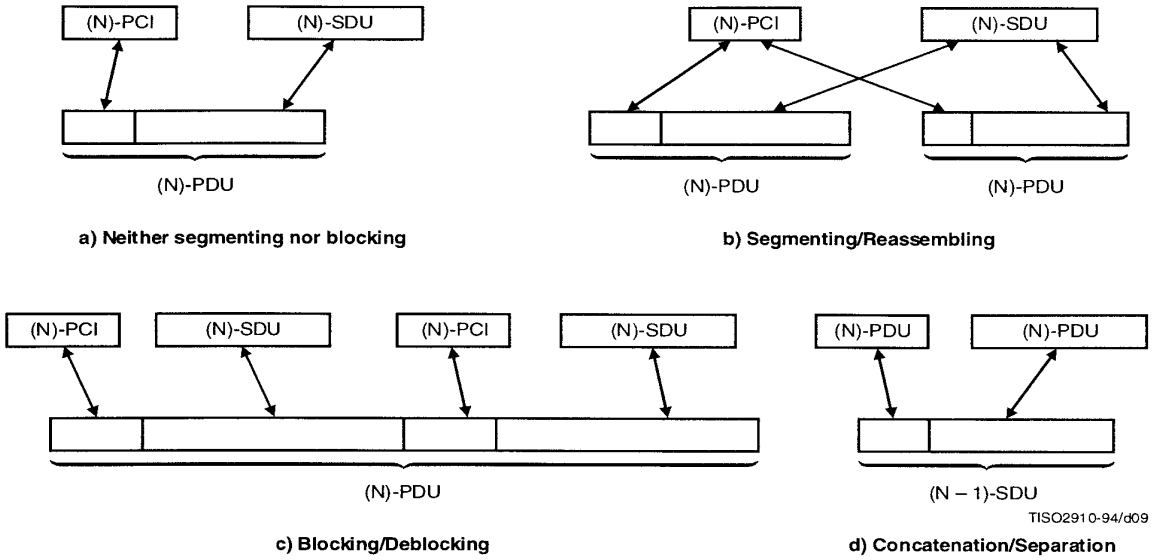
5.8.9.1.2 An acknowledgement function may require that information be included in the (N)-protocol-control-information of (N)-protocol-data-units.

5.8.9.1.3 The scheme for uniquely identifying (N)-protocol-data-units may also be used to support other functions such as detection of duplicate data-units, segmenting and sequencing.

5.8.9.1.4 In connectionless-mode transmission, acknowledgement can only apply to (N)-PDUs, not on (N)-SDUs.

NOTE – Other forms of acknowledgement such as confirmation of delivery and confirmation of performance of an action are for further study.

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SDU Service-data-unit
PCI Protocol-control-information
PDU Protocol-data-unit

NOTES

1 This figure does not imply any potential relationship between protocol-control-information and user-data in protocol-data-units.

2 In the case of concatenation, (N)-protocol-data-unit does not necessarily include an (N)-service-data-unit.

Figure 10 – Relationship between (N)-service-data-units, (N)-protocol-data-units and (N – 1)-service-data-units within a layer

5.8.9.2 Error detection and notification

5.8.9.2.1 Error detection and notification functions may be used by an (N)-protocol to provide a higher probability of both protocol-data-unit error detection and data corruption detection than is provided by the (N–1)-service.

5.8.9.2.2 Error detection and notification may require that additional information be included in the (N)-protocol-control-information of (N)-protocol-data-units.

5.8.9.2.3 In connectionless-mode, while the (N)-service provider may attempt to provide a notification upon detection of data corruption or protocol-data-unit loss, misdelivery etc., it cannot be relied upon to be capable of doing so for every instance of error detection.

5.8.9.3 Reset

5.8.9.3.1 Some services require a reset function to recover from a loss of synchronization between correspondent (N)-entities. A reset function sets the correspondent (N)-entities to a predefined state with a possible loss or duplication of data.

NOTE – Additional functions may be required to determine at what point reliable data transfer was interrupted.

5.8.9.3.2 A quantity of (N)-user-data may be conveyed in association with the (N)-reset function.

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5.8.9.3.3 The reset function may require that information be included in the (N)-protocol-control-information of the (N)-protocol-data-unit.

5.8.9.3.4 The reset function does not apply in connectionless-mode transmission.

5.9 Routing

A routing function within the (N)-layer enables communication to be relayed by a chain of (N)-entities. The fact that communication is being routed by intermediate (N)-entities is known by neither the lower layers nor the higher layers. An (N)-entity which participates in a routing function may have a routing table.

5.10 Quality Of Service (QOS)

5.10.1 Introduction

5.10.1.1 Quality Of Service (QOS) is the collective name given to a set of parameters associated with (N)-data transmission among (N)-service-access-points.

5.10.1.2 There are two categories of quality of service parameters. The first category applies to both connection-mode and connectionless-mode. The second category applies only to the connection-mode service. The lists of parameters given are only examples. Individual parameters are defined for each layer.

5.10.2 Connection/Connectionless parameters

5.10.2.1 These parameters apply for the provision of either the (N)-connection-mode service or the (N)-connectionless-mode service.

5.10.2.2 Single transmission related parameters

5.10.2.2.1 For the (N)-connection-mode service, the parameters are negotiated during establishment of the (N)-connection. For the connectionless-mode service, the parameters are defined entirely by the behavior of a single (N)-data-transmission and are the same as those defined for the (N)-connection-mode service. Possible parameters are:

a) expected transmission delay;

b) probability of corruption;

c) probability of loss or duplication;

d) probablility of wrong delivery;

e) cost;

f) protection from unauthorized access; and

g) priority.

5.10.2.3 Multiple transmission related parameters

5.10.2.3.1 The parameters apply for multiple (N)-data-transmissions between pairs of (N)-service-access-points. Possible parameters are:

a) expected throughput; and

b) probability of out of sequence delivery.

5.10.3 Connection-mode parameters

5.10.3.1 These parameters apply only to the (N)-connection-mode service and are negotiated by (N)-protocol during the establishment of the (N)-connection.

5.10.3.2 Possible parameters are:

a) connection establishment delay;

b) connection establishment failure probability;

c) connection release delay;

d) connection release failure probability;

e) connection resilience.

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6 Introduction to the specific OSI layers

6.1 Specific layers

6.1.1 The general structure of the OSI architecture described in clause 5 provides architectural concepts from which the Reference Model of Open Systems Interconnection has been derived, making specific choices for the layers and their contents.

6.1.2 The Reference Model contains seven layers:

a) the Application Layer (layer 7);

b) the Presentation Layer (layer 6);

c) the Session Layer (layer 5);

d) the Transport Layer (layer 4);

e) the Network Layer (layer 3);

f) the Data Link Layer (layer 2); and

g) the Physical Layer (layer 1).

6.1.3 These layers are illustrated in Figure 11.

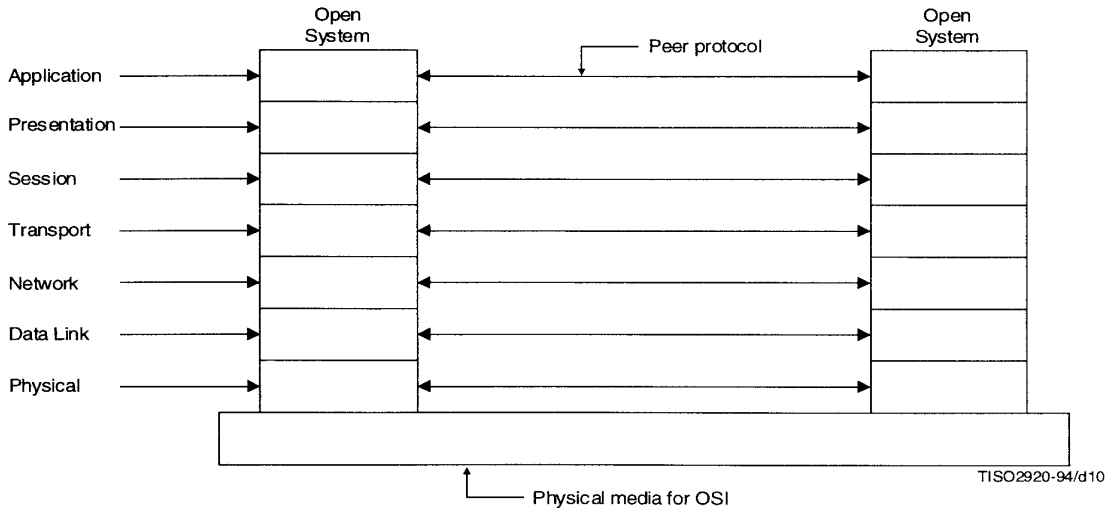


Figure 11 – Seven layer reference model and peer protocols

6.1.4 The highest is the Application Layer and it consists of the application-entities that cooperate in the OSI Environment. The lower layers provide the services through which the application-entities cooperate.

6.1.5 Layers 1 to 6, together with the physical media for OSI provide a step-by-step enhancement of communication services. The boundary between two layers identifies a stage in this enhancement of services at which an OSI service standard is defined while the functioning of the layers is governed by OSI protocol standards.

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6.1.6 Not all open systems provide the initial source or final destination of data. When the physical media for OSI do not link all open systems directly, some open systems act only as relay open systems, passing data to other open systems. The functions and protocols which support the forwarding of data are then provided in the lower layers. This is illustrated in Figure 12.

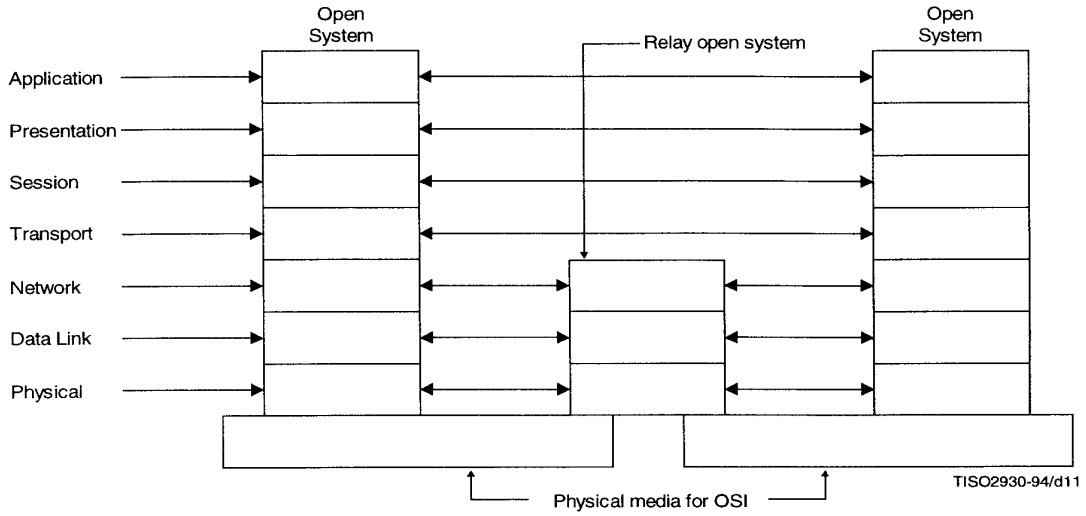


Figure 12 – Communication involving relay open systems

6.2 The principles used to determine the seven layers in the Reference Model

6.2.1 The following principles have been used to determine the seven layers in the Reference Model and are felt to be useful for guiding further decisions in the development of OSI standards:

NOTE – It may be difficult to prove that any particular layering selected is the best possible solution. However, there are general principles which can be applied to the question of where a boundary should be placed and how many boundaries should be placed.

a) Do not create so many layers as to make the system engineering task of describing and integrating the layers more difficult than necessary.

b) Create a boundary at a point where the description of services can be small and the number of interactions across the boundary are minimized.

c) Create separate layers to handle functions that are manifestly different in the process performed or the technology involved.

d) Collect similar functions into the same layer.

e) Select boundaries at a point which past experience has demonstrated to be successful.

f) Create a layer of easily localized functions so that the layer could be totally redesigned and its protocols changed in a major way to take advantage of new advances in architectural, hardware or software technology without changing the services expected from and provided to the adjacent layers.

g) Create a boundary where it may be useful at some point in time to have the corresponding interface standardized.

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NOTES

1 Advantages and drawbacks of standardizing internal interfaces within open systems are not considered in this Recommendation | International Standard. In particular, mention of, or reference to principle g), should not be taken to imply usefulness of standards for such internal interfaces.

2 It is important to note that OSI *per se* does not require interfaces within open systems to be standardized. Moreover, whenever standards for such interfaces are defined, adherence to such internal interface standards can in no way be considered as a condition of openness.

h) Create a layer where there is a need for a different level of abstraction in the handling of data, for example morphology, syntax, semantics.

j) Allow changes of functions or protocols to be made within a layer without affecting other layers; and

k) create for each layer, boundaries with its upper and lower layer only.

Similar principles have been applied to sublayering:

m) Create further subgrouping and organization of functions to form sublayers within a layer in cases where distinct communication services need it.

n) Create, where needed, two or more sublayers with a common, and therefore minimal functionality to allow interface operation with adjacent layers; and

p) allow by-passing of sublayers.

6.3 Layer descriptions

6.3.1 For each of the seven layers identified above, clause 7 provides:

a) an outline of the purpose of the layer;

b) a description of the services offered by the layer to the layer above; and

c) a description of the functions provided in the layer and the use made of the services provided by the layer below.

The descriptions, by themselves, do not provide a complete definition of the services and protocols for each layer. These are the subject of separate standards.

6.3.2 The facilities and functions listed in clause 7 for each layer represent the set of architectural possibilities. A service definition derived from these definitions for a particular layer may include some, or all of the facilities and it may be characterized by none, some or all of the QoS parameters defined for the layer in clause 7 and in 5.10. A protocol specification derived from these definitions for a particular layer may invoke some or all of the functions defined for the layer. Such a service or protocol is constrained to not utilize nor invoke facilities or functions that are not listed.

6.4 Combinations of connection-mode and connectionless-mode

6.4.1 The provision of connectionless-mode and connection-mode services in specific layers of the Reference Model and the characteristics of these services, together with the provision of functions providing for conversion within a layer between one mode of service and another, should be such as to ensure that it is possible to determine whether or not interworking between open systems is possible. In order to maximize the possibility of interworking and to limit protocol complexity, there is a restriction on the number of layers within which conversion between one mode of service and the other may take place. This restriction applies to the layers as follows:

a) Special considerations apply to the Physical and Data Link Layers. Connection-mode and connectionless-mode services are not differentiated for the Physical Layer. The services of the Physical Layer are determined by the characteristics of the underlying medium and are too diverse to allow categorization into connection-mode and connectionless-mode operation. Functions in the Data Link Layer must convert between the services offered by the Physical Layer and the type of Data Link service needed.

b) Conversion may be provided in the Network Layer to support a network service of a given mode over a Data Link or subnetwork service of the other mode. This, in conjunction with relaying, provides an end-to-end network service of a given mode over concatenated subnetworks and/or Data Link services of either mode (see 5.3.4). Support of such conversions, where they are necessary to provide a given mode of network service, is a requirement of OSI standards.

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c) Conversion may be provided in the Transport Layer on condition that this makes use of only limited additional protocol functions over those required to support a given mode of transport service over the same mode of network service. Since relaying is not permitted in the Transport Layer, such conversions can only be applied between end-systems. Support for such conversions is not a requirement of OSI standards.

d) Conversion in the Session and Presentation Layer is not permitted.

e) No conversion restrictions are imposed at the Application Layer.

NOTE – It is not possible (since a transport protocol operates between end-systems) for a transport protocol to provide the transport service in an instance of communication between two end-systems utilizing (in that instance of communication) different modes of network service.

6.4.2 It follows from these restrictions that:

a) A real open system as defined in 4.1.2 shall support a given mode of transport service over a network service of the same mode (utilizing conversion within the Network Layer if necessary); such a system may, in addition, provide conversion in the Transport Layer.

b) A real system which only supports a given mode of transport service by providing conversion in the Transport Layer from a network service of the other mode is not fully open as defined in 4.1.2, since such a system would be incapable of communicating with a system which only supports the given mode of transport service over a network service of the same mode.

NOTE – The restriction that a given mode of transport service has to be supported by the same mode of network service is applied so that systems may communicate without requiring prior agreement on the mode of network service to be used. Where prior agreement exists this restriction need not apply, although the requirements for systems to be fully open are as stated in item a) above.

6.5 Configurations of OSI Open Systems

6.5.1 Definitions

6.5.1.1 OSI End System: An open system, which for a particular instance of communication, is the ultimate source or destination of data.

6.5.1.2 OSI-(N)-Relay System: An open system which, for a particular instance of communication, makes use of OSI functions up to and including functions of the (N)-layer and where a relay function is executed within the (N)-layer.

6.5.2 Properties

6.5.2.1 The Reference Model is not restricted to configurations in which only two real open systems participate in an instance of communication nor to configurations in which all participating real open systems are connected to one another by the same physical medium. It also considers configurations in which communication between real open systems involves other real open systems providing relay functions (see 5.3).

6.5.2.2 In order to distinguish between the roles of real open systems involved in an instance of communication, a real open system in which there is an application-process acting either as final source or destination of data is termed an (OSI) end real open system for that instance of communication, and a real open system which is providing a relay function at layer N is termed an OSI (N)-relay system for that instance of communication.

6.5.2.3 From the point of view of a particular instance of communication a real open system may be acting in the role either of an OSI end system or an OSI (N)-relay system, but it does not necessarily act in the same way for all instances of communication in which it is involved. These different views of the same open system may appear successively, or even simultaneously when the open system is engaged in several communications with the same or different open systems.

6.5.2.4 In configurations involving OSI-(N)-relay systems, the Reference Model considers the case where several subnetworks (see 7.5.1) are used in tandem or in parallel (see 7.5.2.3). This involves routing and relaying functions to establish connections through such networks of OSI-(N)-relay systems. Such functions, which support the forwarding of data through OSI-(N)-relay systems, are provided in the lower three layers (see 6.1) or in the Application Layer.

6.5.2.5 In the context of distributed applications, relaying may be performed in application-entities.

6.5.2.6 Thus transport-entities are only involved in instances of communication where the open systems act as OSI end systems or as OSI-(N)-relay systems when the relaying function occurs in the Application Layer.

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7 Detailed description of the resulting OSI architecture

7.1 Application Layer

7.1.1 Definitions

7.1.1.1 application-entity: An active element, within an application process, embodying a set of capabilities which is pertinent to OSI and which is defined for the Application Layer, that corresponds to a specific application-entity-type (without any extra capabilities being used).

7.1.1.2 abstract syntax: The specification of Application-protocol-data-units by using notation rules which are independent of the encoding technique used to represent them.

7.1.2 Purpose

7.1.2.1 As the highest layer in the Reference Model of Open Systems Interconnection, the Application Layer provides the sole means for the application process to access the OSIE. Hence the Application Layer has no boundary with a higher layer.

7.1.2.2 The aspects of an application process which need to be taken into account for the purpose of OSI are represented by one or more application-entities.

7.1.2.3 An application-entity represents one and only one application process in the OSIE. Different application processes may be represented by application-entities of the same application-entity-type. An application process may be represented by a set of application-entitites: each application-entity in this set may be, but need not be, of different application-entity-type.

7.1.3 Services provided by application-entities

7.1.3.1 General

7.1.3.1.1 Application-processes exchange information by means of application-entities which use application-protocols and presentation services.

7.1.3.1.2 As the only layer in the Reference Model that directly provides services to the application-processes, the Application Layer necessarily provides all OSI services directly usable by application-processes.

7.1.3.1.3 There exists no Application Layer service in the sense of (N)-layer service in that there is neither a general service provided to an upper layer nor a relation to a service-access-point.

NOTE – The related concept of OSI-service, defined in ISO/IEC 10731, is applicable in the Application Layer.

7.1.3.2 Connection-mode facilities

In addition to information transfer, such facilities may include, but are not limited to the following:

a) identification of the intended communication partners (for example by name, by address, by definite description, by generic description);

b) determination of the acceptable quality of service (for example response time, tolerable error rate, cost vis-a-vis the previous considerations);

c) synchronization of cooperating applications;

d) agreement on responsibility for error recovery;

e) agreement on security aspects (e.g. authentication, access control, data integrity);

f) selection of mode of dialogue; and

g) identification of abstract syntaxes.

7.1.3.3 Connectionless-mode facilities

7.1.3.3.1 Where appropriate for connectionless-mode operation, equivalent facilities to those provided for connection-mode operation are provided in the Application Layer to application-processes.

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7.1.3.3.2 In addition to information transfer, such facilities constituting the service may include, but are not limited to, the following:

a) identification of intended communication partners;

b) establishment of authority to communicate;

c) authorization of intended communication partners;

d) determination of the acceptable quality of service; and

e) identification of abstract syntaxes.

7.1.4 Functions within the Application Layer

7.1.4.1 The Application Layer contains all those functions which imply communication in either mode between open systems that are not already performed by the lower layers. These include functions performed by programs as well as functions performed by human beings.

7.1.4.2 In particular, application-entities maintain, as part of the pre-knowledge necessary in order to communicate, (or have access to, via use of a directory facility) information on the use of connection-mode and/or connectionless-mode transmission by the peer entities with which they may need to communicate.

7.1.4.3 Groupings of functions in the Application Layer

An application-entity can be structured internally into Application Layer objects representing groups of functions. Use of one grouping of functions may depend on use of some other functions, and the active functions may vary during the lifetime of the application-association.

7.2 Presentation Layer

7.2.1 Definitions

7.2.1.1 **concrete syntax:** Those aspects of the rules used in the formal specification of data which embody a specific representation of that data.

7.2.1.2 **transfer syntax:** The abstract and concrete syntax used in the transfer of data between open systems.

7.2.1.3 **presentation context:** An association of an abstract syntax with a transfer syntax.

7.2.2 Purpose

7.2.2.1 The Presentation Layer provides for the representation of information that application-entities either communicate or refer to in their communication.

7.2.2.2 The Presentation Layer provides for common representation of the data transferred between application-entities. This relieves application-entities of any concern with the problem of "common" representation of information, i.e. it provides them with syntax independence.

7.2.2.3 The Presentation Layer ensures that the information content of the Application Layer data is preserved during transfer. Cooperating application-entities are responsible for determining the set of abstract syntaxes they employ in their communication. The Presentation Layer is informed of the abstract syntaxes that are to be employed. Knowing the set of abstract syntaxes to be used by the application-entities, the Presentation Layer is responsible for selecting mutually acceptable transfer syntaxes.

NOTE – Presentation-entities have no role in determining the set of abstract syntaxes to be used by the application-entities.

7.2.3 Services provided to the Application Layer

7.2.3.1 The Presentation Layer provides the following facilities:

a) identification of a set of transfer syntaxes;

b) selection of transfer syntax; and

c) access to session services.

7.2.3.2 Identification of a set of transfer syntaxes provides one or more means of representing an abstract syntax. Selection of transfer syntax provides the means of initially selecting a transfer syntax and subsequently modifying the selection.

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7.2.3.3 Session services are provided to application-entities in the form of presentation services.

7.2.3.4 In connectionless-mode, segmentation and resassembly are not provided in the Presentation Layer. Thus, the size of presentation-service-data-units is limited by the size of presentation-protocol-data-units and presentation-protocol-control-information.

7.2.4 Functions within the Presentation Layer

The Presentation Layer performs the following functions to help accomplish the presentation-services:

a) negotiation and re-negotiation of transfer syntax;

b) representation of the abstract syntax chosen by the application-entities in the transfer syntax negotiated or renegotiated, including format and special purpose transformations (for example, data compression);

c) restoration of previously negotiated syntaxes on the occurrence of certain events; and

d) use of session-services.

7.2.4.1 Representation of abstract syntax

7.2.4.1.1 Application-entities agree on the abstract syntaxes that will be used for their communication. It is necessary that these abstract syntaxes are represented in appropriate transfer syntaxes for communication to take place.

NOTE – Within a real open system, data defined in terms of an abstract syntax will be represented within the local system environment by a local concrete syntax. A transformation may be necessary between the local concrete syntax and the transfer syntax. Thus, in communication between real open systems there are three concrete syntax versions of the data: the concrete syntax used by the originating application-entity, the concrete syntax used by the receiving application-entity, and the concrete syntax used between the presentation-entities (the transfer syntax). It is clearly possible that any or all of these syntaxes be identical. The local concrete syntaxes are not visible within the OSIE.

7.2.4.1.2 The fact that there is or is no actual transformation of concrete syntax has no impact on the presentation-protocol.

7.2.4.1.3 There is not a single predetermined transfer syntax for all OSI. In connection-mode, the transfer syntax to be used on a presentation-connection is negotiated between the correspondent presentation-entities.

7.2.4.1.4 In connectionless-mode, the transfer syntax is selected, but cannot be negotiated.

7.2.4.2 Negotiation of transfer syntax

7.2.4.2.1 Negotiation (or selection) of transfer syntax takes place between two presentation-entities when an application-entity provides the name of an abstract syntax for which a transfer syntax is required.

7.2.4.2.2 In general, there may be more than one combination of abstract syntax and transfer syntax. It may be possible to represent a specific abstract syntax by one or more transfer syntaxes; also it may be possible to use one transfer syntax to represent more than one abstract syntax. Each combination of abstract syntax and transfer syntax is called a presentation context. From the viewpoint of the application-entity, a presentation context represents a specific distinct use of an abstract syntax.

7.2.4.3 Addressing and Multiplexing

There is no multiplexing or splitting in the Presentation Layer.

7.3 Session Layer

7.3.1 Definitions

7.3.1.1 token management: A facility of the session-service which allows correspondent presentation-entities to control explicitly whose right it is to exercise certain session-services.

7.3.1.2 duplex mode: A mode of interaction where both presentation-entities may concurrently send and receive normal data.

7.3.1.3 half-duplex mode: A mode of interaction where, at a given instance, only one of the two correspondent presentation-entities is allowed to send normal data.

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7.3.1.4 session-connection synchronization: A facility of the session-service which allows presentation-entities to define and to identify synchronization points and to reset a session-connection to a predefined state and to agree on a resynchronization point.

7.3.2 Purpose

7.3.2.1 The purpose of the Session Layer is to provide the means necessary for cooperating presentation-entities to organize and to synchronize their dialogue and to manage their data exchange. To do this, the Session Layer provides services to establish a session-connection between two presentation-entities, to support orderly data exchange interactions, and to release the connection in an orderly manner.

7.3.2.2 The only function of the Session Layer for connectionless-mode communication is to provide a mapping of transport-addresses to session-addresses.

7.3.2.3 A session-connection is created when requested by a presentation-entity at a session-service-access-point. The session-connection exists until it is released by either the presentation-entities or the session-entities.

7.3.2.4 The initiating presentation-entity designates the destination presentation-entity by a session address. In general, there is a many-to-one correspondence between the session-addresses and transport-addresses. This does not imply multiplexing of session-connections onto transport-connections, but does imply that at session-connection establishment time, more than one presentation-entity is a potential target of a session-connection establishment request arriving on a given transport-connection. However, when needed, there may be a one-to-one correspondence between the session-address and the transport-address.

7.3.3 Services provided to the Presentation Layer

7.3.3.1 General

7.3.3.1.1 In connection-mode, the services provided by the Session Layer are described below:

a) session-connection establishment;

b) session-connection release;

c) normal data transfer;

d) expedited data transfer;

e) token management;

f) session-connection synchronization;

g) exception reporting;

h) activity management;

j) typed data transfer; and

k) resynchronization.

7.3.3.1.2 In connectionless-mode, the Session Layer provides the following services:

a) connectionless-mode transmission using the transport-connectionless-mode service; and

b) exception reporting.

7.3.3.1.3 In connectionless-mode, segmentation and resassembly are not provided in the Session Layer. Thus, the size of session-service-data-units is limited by the size of session-protocol-data-units and session-protocol-control-information.

7.3.3.2 Session-connection establishment

7.3.3.2.1 The session-connection establishment service enables two presentation-entities to establish a session-connection between them. The presentation-entities are identified by session-addresses used to request the establishment of the session-connection.

7.3.3.2.2 The session-connection establishment service allows the presentation-entities to determine cooperatively the unique values of session-connection parameters at the time the session-connection is established.

7.3.3.2.3 The session-connection establishment service provides a session-connection identification parameter which allows the presentation-entities to identify the session-connection.

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7.3.3.3 Session-connection release

7.3.3.3.1 The session-connection release service allows presentation-entities to release a session-connection in a orderly way without loss of data. It also allows either presentation-entity to request at any time that a session-connection be aborted; in this case, data may be lost.

7.3.3.3.2 A session-connection may also be aborted by one of the session-entities supporting it.

7.3.3.4 Normal data transfer

The normal data transfer service allows a sending presentation-entity to transfer a session-service-data-unit to a receiving presentation-entity.

7.3.3.5 Expedited data transfer

The expedited data transfer service provides expedited handling of the transfer of expedited session-service-data-units. A specific size restriction is placed on expedited session-service-data-units.

7.3.3.6 Token management

The token management service allows the presentation-entities to control explicitly whose turn it is to exercise certain control functions.

7.3.3.7 Session-connection synchronization

7.3.3.7.1 The session-connection synchronization service allows presentation-entities:

a) to define and identify synchronization points; and

b) to reset the session-connection to a defined state and agree on a resynchronization point with the potential of the loss of data.

7.3.3.7.2 Any semantics which session-service users may give to their synchronization points are transparent to the session-service provider.

7.3.3.7.3 The Session Layer is not responsible for any associated checkpointing or commitment action associated with synchronization.

7.3.3.7.4 Symmetric synchronization allows synchronization points to be set independently on the two directions of the flow.

7.3.3.8 Exception reporting

The exception reporting service permits the presentation-entities to be notified of exceptional situations.

7.3.3.9 Activity management

The activity concept allows session-service users to distinguish logical pieces of work called activities. Each activity consists of one or more dialog units. Only one activity is allowed on a session-connection at a time, but there may be serveral consecutive activities during a session-connection. An activity may also span more than one session-connection. Activities can also be interrupted and then resumed on the same or a subsequent session-connection.

7.3.3.10 Typed Data Transfer

The typed data transfer service allows a sending presentation-entity to transfer a session-service-data-unit to a receiving presentation-entity independent of the provisions of token management.

7.3.3.11 Resynchronization

Resynchronization may be initiated by either session-service user. It sets the session-connection to a defined state and therefore includes reassignment of tokens and setting the synchronization point serial number to a new value. Resynchronization may purge undelivered data.

7.3.4 Functions within the Session Layer

7.3.4.1 The functions within the Session Layer are those which shall be performed by session-entities in order to provide the session-services. When providing the connectionless-mode service, the Session Layer provides a one-to-one mapping of Session-connectionless-mode-transmissions onto transport-connectionless-mode-transmissions.

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7.3.4.2 Most of the functions required are readily implied by the services provided. Additional description is given below for the following functions:

a) session-connection to transport-connection mapping; and

b) session-connection flow control.

7.3.4.3 Session-connection to transport-connection mapping

There is a one-to-one mapping between a session-connection and a transport-connection at any given instant. However, the lifetime of a transport-connection and that of a related session-connection can be distinguished so that a transport-connection supports several consecutive session-connections.

7.3.4.4 Session-connection flow control

There is no peer flow control in the Session Layer. To prevent the receiving presentation-entity from being overloaded with data, the receiving session-entity applies back pressure across the transport-connection using the transport flow control.

7.4 Transport Layer

7.4.1 Definitions

No Transport Layer specific terms are identified.

7.4.2 Purpose

7.4.2.1 The transport-service provides transparent transfer of data between session-entities and relieves them from any concern with the detailed way in which reliable and cost effective transfer of data is achieved.

7.4.2.2 The Transport Layer optimizes the use of the available network-service to provide the performance required by each session-entity at minimum cost. This optimization is achieved within the constraints imposed by the overall demands of all concurrent session-entities and the overall quality and capacity of the network-service available to the Transport Layer.

7.4.2.3 All protocols defined in the Transport Layer have end-to-end significance, where the ends are defined as transport entities having transport associations. Therefore, the Transport Layer is OSI end open system oriented and transport-protocols operate only between OSI end open systems.

7.4.2.4 The Transport Layer is relieved of any concern with routing and relaying since the network-service provides data transfer from any transport-entity to any other, including the case of tandem subnetworks (see 7.5.1).

7.4.2.5 The transport functions invoked in the Transport Layer to provide a requested service quality depend on the quality of the network-service. The quality of the network-service depends on the way the network-service is achieved (see 7.5.3).

7.4.3 Services provided to the Session Layer

7.4.3.1 Introduction

7.4.3.1.1 The Transport Layer uniquely identifies each session-entity by its transport-address. When providing the connectionless-mode service, the Transport Layer provides a connectionless-mode service which maps a request for transmission of a transport-service-data-unit onto a request to the connectionless-mode network-service. In connection-mode, the transport-service provides the means to establish, maintain, and release transport-connections. Transport-connections provide duplex transmission between a pair of session-entites (through transport-SAPs).

7.4.3.1.2 More than one transport-connection can be established between the same pair of transport-addresses. A session-entity uses transport-connection-endpoint-identifiers provided by the Transport Layer to distinguish between transport-connection-endpoints.

7.4.3.1.3 The operation of one transport-connection is independent of the operation of all others except for the limitations imposed by the finite resources available to the Transport Layer.

7.4.3.1.4 The quality of service provided on a transport-connection depends on the service class requested by the session-entities when establishing the transport-connection. The selected quality of service is maintained throughout the lifetime of the transport-connection. The session-entity is notified of any failure to maintain the selected quality of service on a given transport-connection.

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7.4.3.1.5 In connection-mode, the following facilities provided by the Transport Layer are described below:

a) transport-connection establishment;

b) transport-connection release;

c) data transfer;

d) expedited data transfer; and

e) suspend facility.

7.4.3.1.6 In connectionless-mode, segmentation and resassembly are not provided in the Transport Layer. Thus, the size of transport-service-data-units is limited by the size of transport-protocol-data-units and transport-protocol-control-information.

7.4.3.2 Transport-connection establishment

7.4.3.2.1 Transport-connections are established between session-entities identified by transport-addresses. The quality of service of the transport-connection is negotiated between the session-entities and the transport-service.

7.4.3.2.2 At the time of establishment of a transport-connection the class of transport-service to be provided can be selected from a defined set of available classes of service.

7.4.3.2.3 These service classes are characterized by combinations of selected values of parameters such as throughput, transit delay, and connection set-up delay and by guaranteed values of parameters such as residual error rate and service availability.

7.4.3.2.4 These classes of service represent globally predefined combinations of parameters controling quality of service. These classes of service are intended to cover the transport-service requirements of the various types of traffic generated by the session-entities.

7.4.3.3 Transport-connection release

This facility provides the means by which either session-entity can release a transport-connection and have the correspondent session-entity informed of the release.

7.4.3.4 Data transfer

This facility provides data transfer in accordance with the agreed quality of service. When the quality of service cannot be maintained and all possible recovery attempts have failed, the transport-connection is terminated and the session-entities are notified.

a) The transport-service-data-unit transfer service provides the means by which transport-service-data-units of arbitrary length are delimited and transparently transferred in sequence from one sending transport-service-access-point to the receiving transport-service-access-point over a transport-connection. This service is subject to flow control.

b) The expedited transport-service-data-unit transfer service provides an additional means of information exchange on a transport-connection. The expedited transport-data-units are subject to their own set of transport-service and flow control characteristics. The maximum size of expedited transport-service-data-units is limited.

7.4.3.5 Expedited Data

An expedited service is provided by the Transport Layer. However, it should be used in accordance with the constraints described in 5.8.8.3.

7.4.4 Functions within the Transport Layer

7.4.4.1 General

7.4.4.1.1 In connection-mode, the Transport Layer functions may include:

a) mapping transport-address onto a network-address;

b) multiplexing (end-to-end) transport-connections onto network-connections;

c) establishment and release of transport-connections;

d) end-to-end sequence control on individual connections;

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e) end-to-end error detection and any necessary monitoring of the quality of service;

f) end-to-end error recovery;

g) end-to-end segmenting, blocking, and concatenation;

h) end-to-end flow control on individual connections;

j) supervisory functions;

k) expedited transport-service-data-unit transfer; and

l) suspend/resume.

7.4.4.1.2 In connectionless-mode, the Transport Layer provides the following functions to support connectionless-mode transmission:

a) mapping between transport-addresses and network-addresses;

b) mapping end-to-end transport-connectionless-mode transmissions on to network-connectionless-mode transmissions;

NOTE – There may be specific situations where performing conversion from connection-mode to connectionless-mode operation in the Transport Layer can be justified and may thus be permitted provided that this requires only limited extensions to existing protocols. In such cases it is accepted that communication using such conversions can only take place betweeen OSI end systems supporting them (see 6.4).

c) end-to-end error detection and monitoring of the quality of service;

d) transport-service-data-unit delimiting; and

e) supervisory functions.

7.4.4.2 Addressing

7.4.4.2.1 When a session-entity requests the Transport Layer to establish a transport-connection with another session-entity identified by its transport-address, the Transport Layer determines the network-address identifying the transport-entity which serves the correspondent session-entity.

7.4.4.2.2 Because transport-entities support services on an end-to-end basis no intermediate transport-entity is involved as a relay between the end transport-entities. Therefore the Transport Layer maps transport-addresses to the network-addresses which identify the end transport-entities (see Figure 13).

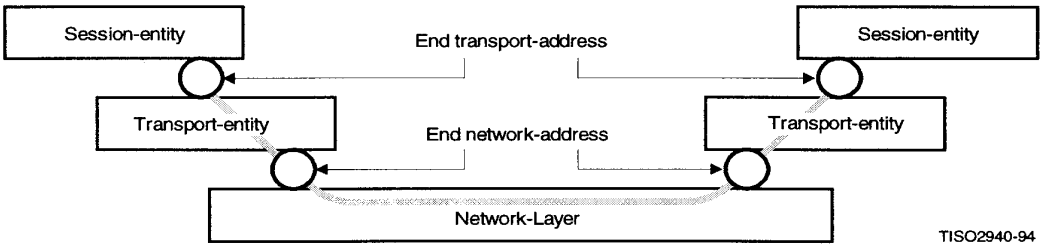


Figure 13 – Association of transport-addresses and network address

7.4.4.2.3 One transport-entity may serve more than one session-entity. Several transport-addresses may be associated with one network-address within the scope of the same transport-entity. Corresponding mapping functions are performed within the transport-entities to provide these facilities (see Figure 14).

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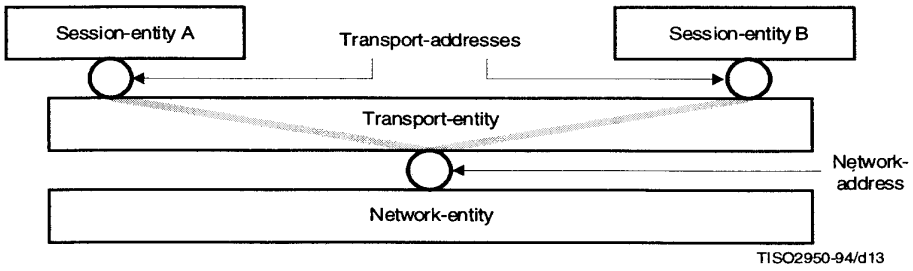


Figure 14 – Association of one network address with several transport addresses

7.4.4.3 Connection multiplexing and splitting

In order to optimize the use of network-connections, the mapping of transport-connections onto network-connections need not be on a one-to-one basis. Both splitting and multiplexing may be performed, namely for optimizing the cost of usage of the network-service.

7.4.4.4 Phases of operation

In connection-mode operation, the phases of operation within the Transport Layer are:

a) establishment phase;

b) data transfer phase; and

c) release phase.

The transfer from one phase of operation to another is specified in detail within the protocol for the Transport Layer.

7.4.4.5 Establishment phase

During the establishment phase, the Transport Layer establishes a transport-connection between two session-entities. The functions of the Transport Layer during this phase match the requested class of service with the services provided by the Network Layer. The following functions can be performed during this phase:

a) obtain a network-connection which best matches requirements of the session-entity, taking into account cost and quality of service;

b) decide whether multiplexing or splitting is needed to optimize the use of network-connections;

c) establish the optimum transport-protocol-data-unit size;

d) select the functions that will be operational upon entering the data transfer phase;

e) map transport-addresses onto network-addresses;

f) provide identification of different transport-connections between the same pair of transport-service-access-points (connection identification function); and

g) transfer of data.

7.4.4.6 Data transfer phase

The purpose of the data transfer phase is to transfer transport-service-data-units between the two session-entities connected by the transport-connection. This is achieved by the transportation of transport-protocol-data-units and by the following functions, each of which is used or not used according to the class of service selected in the establishment phase:

a) sequencing;

b) blocking;

c) concatenation;

d) segmenting;

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e) multiplexing or splitting;

f) flow control;

g) error detection;

h) error recovery;

j) expedited data transfer;

k) transport-service-data-unit delimiting; and

m) transport-connection identification.

7.4.4.7 Release phase

The purpose of the release phase is to release the transport-connection. It may include the following functions:

a) notification of reason for release;

b) identificaton of the transport-connection released; and

c) transfer of data.

7.4.4.8 Transport Layer management

The Transport Layer protocols deal with some management activities of the layer (such as activation and error control). See clause 8 and ITU-T Rec. X.700 | ISO 7498-4 for the relationship with other management aspects.

7.5 Network Layer

7.5.1 Definitions

7.5.1.1 real subnetwork: A collection of equipment and physical media which forms an autonomous whole and which can be used to interconnect real systems for the purpose of data transfer.

7.5.1.2 subnetwork: An abstraction of a real subnetwork.

NOTES

1 A subnetwork is a representation within the OSI Reference Model of a real network such as a carrier network, a private network, or a local area network.

2 A subnetwork may itself be an open system, although this is not necessarily always the case. See ISO 8648 – Internal Organization of the Network Layer.

7.5.1.3 subnetwork-connection: A communication path through a subnetwork which is used by entities in the Network Layer in providing a network-connection.

7.5.2 Purpose

7.5.2.1 The Network Layer provides the functional and procedural means for connectionless-mode or connection-mode transmission among transport-entities and, therefore, provides to the transport-entities independence of routing and relay considerations.

7.5.2.2 The Network Layer provides the means to establish, maintain, and terminate network-connections between open systems containing communicating application-entities and the functional and procedural means to exchange network-service-data-units between transport-entities over network-connections.

7.5.2.3 It provides to the transport-entities independence from routing and relay consideration associated with the establishment and operation of a given network-connection. This includes the case where several subnetworks are used in tandem (see 7.5.4.2) or in parallel. It makes invisible to transport-entities how underlying resources such as data-link-connections are used to provide network-connections.

7.5.2.4 Any relay functions and hop-by-hop service enhancement protocols used to support the network-service between the OSI end systems are operating below the Transport Layer, i.e. within the Network Layer or below.

7.5.3 Service provided to the Transport Layer

7.5.3.1 Introduction

7.5.3.1.1 The basic service of the Network Layer is to provide the transparent transfer of data between transport-entities. This service allows the structure and detailed content of submitted data to be determined exclusively by layers above the Network Layer.

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7.5.3.1.2 All facilities are provided to the Transport Layer at a known cost.

7.5.3.1.3 The Network Layer contains functions necessary to provide the Transport Layer with a firm Network/Transport Layer boundary which is independent of the underlying communications media in all things other than quality of service. Thus the Network Layer contains functions necessary to mask the differences in the characteristics of different transmission and subnetwork technologies into a consistent network service.

7.5.3.1.4 The service provided at each end of a network-connection is the same even when a network-connection spans several subnetworks, each offering dissimilar services (see 7.5.4.2).

NOTE – It is important to distinguish the specialized use of the term "service" within the OSI Reference Model from its common use by suppliers of private networks and carriers.

7.5.3.1.5 The quality of service is negotiated between the transport-entities and the network-service at the time of establishment of a network-connection. While this quality of service may vary from one network-connection to another it will be agreed for a given network-connection and be the same at both network-connection-endpoints.

7.5.3.1.6 In connection-mode, the facilities provided by the Network Layer are described below:

a) network-addresses;

b) network-connections;

c) network-connection-endpoint-identifiers;

d) network-service-data-unit transfer;

e) quality of service parameters;

f) error notification;

g) expedited network-service-data-unit transfer ;

h) reset;

j) release; and

k) receipt of confirmation.

7.5.3.1.7 Some of these facilities are optional. This means that:

a) the user has to request the facilities; and

b) the network-service provider may honour the request or indicate that the service is not available.

7.5.3.1.8 In connectionless-mode, the facilities provided by the Network Layer, operating among network-service-access-points, are:

a) transmission of network-service-data-units of a defined maximum size;

b) quality of service parameters; and

c) local error notification.

7.5.3.2 Network-addresses

Transport-entities are known to the Network Layer by means of network-addresses. Network-addresses are provided by the Network Layer and can be used by transport-entities to identify uniquely other transport-entities, i.e. network-addresses are necessary for transport-entities to communicate using the network-service. The Network Layer uniquely identifies each of the end open systems (represented by transport-entities) by their network-addresses. This may be independent of the addressing needed by the underlaying layers.

7.5.3.3 Network-connections

7.5.3.3.1 A network-connection provides the means of transferring data between transport-entities identified by network-SAP-addresses. The Network Layer provides the means to establish, maintain and release network-connections.

7.5.3.3.2 A network-connection is point-to-point.

7.5.3.3.3 More than one network-connection may exist between the same pair of transport-entities (through the network-SAP-addresses).

7.5.3.4 Network-connection-endpoint-identifiers

The Network Layer provides to the transport-entity a network-connection-endpoint-identifier which uniquely identifies the network-connection-endpoint with the associated network-SAP-address.

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7.5.3.5 Network-service-data-unit transfer

7.5.3.5.1 On a network-connection, the Network Layer provides for the transmission of network-service-data-units. These units have a distinct beginning and end and the integrity of the unit's content is maintained by the Network Layer.

7.5.3.5.2 In connection-mode, no limit is imposed on the maximum size of network-service-data-units.

7.5.3.5.3 The network-service-data-units are transferred transparently between transport-entities.

7.5.3.6 Quality of service parameters

7.5.3.6.1 The Network Layer establishes and maintains a selected qualilty of service for the duration of the network-connection.

7.5.3.6.2 The quality of service parameters include residual error rate, service availability, reliability, throughput, transit delay (including variations), and delay for network-connection establishment.

7.5.3.7 Error notification

7.5.3.7.1 Unrecoverable errors detected by the Network Layer are reported to the transport-entities.

7.5.3.7.2 Error notification may or may not lead to the release of the network-connection, according to the specification of a particular network-service.

7.5.3.8 Expedited network-service-data-unit transfer

7.5.3.8.1 The expedited network-service-data-unit transfer is optional and provides an additional means of information exchange on a network-connection. The transfer of a expedited network-service-data-units is subject to a different set of network-service characteristics and to separate flow control.

7.5.3.8.2 The maximum size of an expedited network-service-data-unit is limited.

7.5.3.8.3 This service is an optional service that may not always be available.

7.5.3.9 Reset

The reset facility is optional and when invoked causes the Network Layer to discard all network-service-data-units in transit on the network-connection and to notify the transport-entity at the other end of the network-connection that a reset has occurred.

7.5.3.10 Release

7.5.3.10.1 A transport-entity may request release of a network-connection. The network-service does not guarantee delivery of data preceding the release request and still in transit. The network-connection is released regardless of the action taken by the correspondent transport-entity.

7.5.3.10.2 This facility is optional and may not always be available.

7.5.3.11 Receipt confirmation

7.5.3.11.1 A transport-entity may confirm receipt of data over a network-connection. The use of the receipt confirmation service is agreed by the two users of the network-connection during connection establishment.

7.5.3.11.2 This service is optional and may not always be available.[4)]

7.5.4 Functions within the Network Layer

7.5.4.1 Introduction

7.5.4.1.1 Network Layer functions provide for the wide variety of configurations supporting network-connections ranging from network-connections supported by point-to-point configurations to network-connections supported by complex combinations of subnetworks with different characteristics.

NOTE – In order to cope with this wide variety of cases, network functions should be structured into sublayers. The subdivision of the Network Layer into sublayers need only be done when this is useful. In particular, sublayering need not be used when the access protocol to the subnetwork supports the complete functionality of the OSI network-service.

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4) This service is included in the network-service only to support existing features of ITU-T Rec. X.25.

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7.5.4.1.2 The following are functions performed by the Network Layer:

a) routing and relaying;

b) network-connections;

c) network-connection multiplexing;

d) segmenting and blocking;

e) error detection;

f) error recovery;

g) sequencing;

h) flow control;

j) expedited data transfer;

k) reset;

m) service selection;

n) mapping between network-addresses and data-link addresses;

o) mapping network-connectionless-mode transmissions to data-link-connectionless-mode transmissions;

p) converting from data-link-connection-mode service to network-connectionless-mode service;

q) enhancing a data-link-connectionless mode service to provide a network-connection-mode service; and

r) network layer management.

7.5.4.2 Routing and relaying

7.5.4.2.1 Network-connections are provided by network-entities in OSI end systems and by intermediate open systems which provide relaying. These intermediate open systems may interconnect subnetwork-connections, data-link-connections, and data-circuits (see 7.7). Routing functions determine an appropriate route between network-addresses. In order to set up the resulting communication, it may be necessary for the Network Layer to use the services of the Data Link Layer to control the interconnection of data-circuits (see 7.6.4.10 and 7.7.3.1).

7.5.4.2.2 The control of interconnection of data-circuits (which are in the Physical Layer) from the Network Layer requires interaction between a network-entity and a physical-entity in the same open system. Since the Reference Model permits direct interaction only between adjacent layers, the network-entity cannot interact directly with the physical-entity. This interaction is thus described through the Data Link Layer which intervenes transparently to convey the interaction between the Network Layer and the Physical Layer.

7.5.4.2.3 This representation of the control of data-circuit interconnection is an abstract representation. It is a local matter in an open system. It does not model the functioning of real open systems and as such has no impact on the standardization of OSI protocols.

NOTE – When Network Layer functions are performed by combinations of several individual subnetworks, the specification of routing and relaying functions could be facilitated by using sublayers, isolating individual subnetworks routing and relaying functions from internetwork routing and relaying functions. However, when subnetworks have access protocols supporting the complete functionality of the OSI network service, there need be no sublayering in the Network Layer.

7.5.4.3 Network-connections

7.5.4.3.1 This function provides network-connections between transport-entities, making use of data-link-connections provided by the Data Link Layer.

7.5.4.3.2 A network-connection may also be provided as subnetwork-connections in tandem, i.e. using several individual subnetworks in series. The interconnected individual subnetworks may have the same or different service capabilities. Each end of a subnetwork-connection may operate with a different subnetwork protocol.

7.5.4.3.3 The interconnection of a pair of subnetworks of differing qualities may be achieved in two ways. To illustrate these, consider a pair of subnetworks, one of high quality and the other of low quality:

a) The two subnetworks are interconnected as they stand. The quality of the resulting network-connection is not higher than that of the lower quality subnetwork (see Figure 15).

b) The lower quality subnetwork is enhanced to equal the higher quality subnetwork and the subnetworks are then interconnected. The quality of the resulting network-connection is approximately that of the higher quality subnetwork (see Figure 16).

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The choice between these two alternatives depends on the degree of difference in quality, the cost of enhancement, and other economic factors.

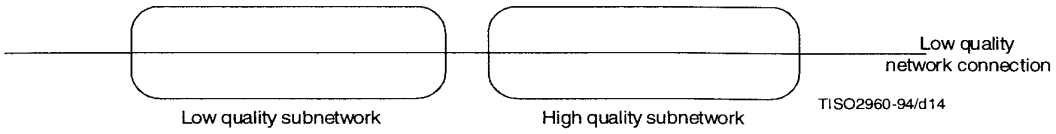


Figure 15 – Interconnection of a low quality and a high quality subnetwork

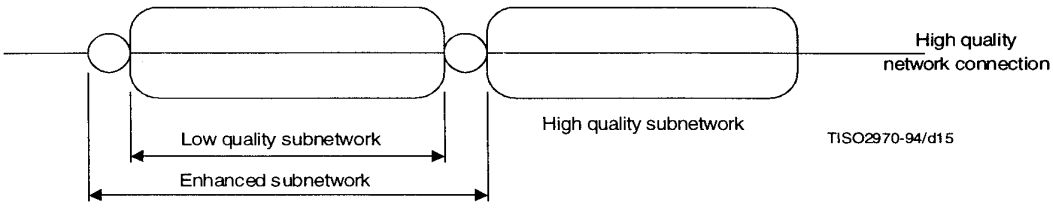


Figure 16 – Interconnection of an enhaned low quality subnetwork and a high quality subnetwork

7.5.4.4 Network-connection multiplexing

7.5.4.4.1 This function may be used to multiplex network-connections onto data-link-connections in order to optimize their use.

7.5.4.4.2 In the case of subnetwork-connections in tandem, multiplexing onto individual subnetwork-connections may also be performed in order to optimize their use.

7.5.4.5 Segmenting and blocking

The Network Layer may segment and/or block network-service-data-units for the purpose of facilitating the transfer. However, the network-service-data-unit delimiters are preserved over the network-connection.

7.5.4.6 Error detection

Error detection functions are used to check that the quality of service provided over a network-connection is maintained. Error detection in the Network Layer uses error notification from the Data Link Layer. Additional error detection capabilities may be necessary to provide the required quality of service.

7.5.4.7 Error recovery

This function provides for the recovery from detected errors. This function may vary depending on the quality of the network service provided.

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7.5.4.8 Sequencing

This function provides for the sequenced delivery of network-service-data-units over a given network-connection when requested by a transport-entity.

7.5.4.9 Flow control

If flow control is required, this function may need to be performed.

7.5.4.10 Expedited data transfer

This function provides for the expedited data transfer facility.

7.5.4.11 Reset

This function provides for the reset service.

7.5.4.12 Service selection

This function allows service selection to be carried out to ensure that the service provided at each end of a network-connection is the same when a network-connection spans several subnetworks of dissimilar quality.

7.5.4.13 Network Layer management

The Network Layer protocols deal with some management activities of the layer (such as activation and error control). See clause 8 and ITU-T Rec. X.700 | ISO 7498-4 for the relationship with other management aspects.

7.6 Data Link Layer

7.6.1 Definitions

No Data Link Layer specific terms are identified.

7.6.2 Purpose

7.6.2.1 The Data Link Layer provides functional and procedural means for connectionless-mode among network-entities, and for connection-mode for the establishment, maintenance, and release data-link-connections among network-entities and for the transfer of data-link-service-data-units. A data-link-connection is built upon one or several physical-connections.

7.6.2.2 The Data Link Layer detects and possibly corrects errors which may occur in the Physical Layer.

7.6.2.3 In addition, the Data Link Layer enables the Network Layer to control the interconnection of data-circuits within the Physical Layer.

7.6.3 Service provided to the Network Layer

7.6.3.1 In connection-mode, the facilities provided by the Data Link Layer are:

a) data-link-addresses;

b) data-link-connection;

c) data-link-service-data-units;

d) data-link-connection-endpoint-identifiers;

e) error notification;

f) quality of service parameters; and

g) reset.

7.6.3.2 In connectionless-mode, the facilities provided by the Data Link Layer are:

a) data-link-addresses;

b) transmission of data-link-service-data-units of a defined maximum size; and

c) quality of service parameters.

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7.6.3.3 Data-link-addresses

Network-entities are known to the Data Link Layer by means of data-link-addresses. Data-link-addresses are provided by the Data Link Layer and can be used by network-entities to identify other network-entities which communicate using the data link service. A data-link-address is unique within the scope of the set of Open Systems attached to a common Data Link Layer. The notion of a data-link-address is distinct from that of a data-link-service-access-point-address (DLSAP address).

7.6.3.4 Data-link-connection

A data-link-connection provides the means of transferring data between network-entities identified by data-link-addresses. A data-link-connection is established and released dynamically.

7.6.3.5 Data-link-service-data-units

7.6.3.5.1 The Data Link Layer allows exchange of data-link-service-data-units over a data-link-connection or exchange of data-link-service-data-units (that bear no relation to any other data-link-service-data-units) using the connectionless-mode data-link-service.

7.6.3.5.2 The size of the data-link-service-data-units may be limited by the relationship between the physical-connection error rate and the Data Link Layer error detection capability.

7.6.3.6 Data-link-connection-endpoint-identifiers

If needed, the Data Link Layer provides data-link-connection-endpoint-identifiers that can be used by a network-entity to identify a correspondent network-entity.

7.6.3.7 Error notification

Notification is provided to the network-entity when any unrecoverable error is detected by the Data Link Layer.

7.6.3.8 Quality of service parameters

Quality of service parameters may be optionally selectable. The Data Link Layer establishes and maintains a selected quality of service for the duration of the data-link-connection. The quality of service parameters include mean time between detected but unrecoverable errors, residual error rate (where errors may arise from alteration, loss, duplication, misordering, misdelivery of data-link-service-data-units, and other causes), service availability, transit delay and throughput.

7.6.3.9 Reset

The network-entity can force the data-link-entity-invocation into a known state by invoking the reset facility.

7.6.4 Functions within the Data Link Layer

In connection-mode and connectionless-mode, the functions performed by the Data Link Layer are:

a) data-link-service-data-unit mapping;

b) identification and parameter exchange;

c) control of data-circuit interconnection;

d) error detection;

e) routing and relaying; and

f) data Link Layer management.

In connection-mode, the following functions are also performed by the Data Link Layer:

a) data-link-connection establishment and release;

b) connection-mode data-link data transmission;

c) data-link-connection splitting;

d) sequence control;

e) delimiting and synchronization;

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f) flow control;

g) error recovery; and

h) reset.

In connectionless-mode, the following function is also performed by the Data Link Layer:

a) connectionless-mode data-link data transmission.

7.6.4.1 Data-link-connection establishment and release

These functions establish and release data-link-connections on activated physical-connections. When a physical-connection has multiple endpoints (for example multipoint connection) a specific function is needed within the Data Link Layer to identify the data-link-connections using such a physical-connection.

7.6.4.2 Connectionless-mode data-link-data transmission

The connectionless-mode data-link-data transmission provides the means for the transmission of data-link-service-data-units between data-link-service-access-points without establishing a data-link-connection.

7.6.4.3 Data-link-service-data-unit mapping

This function maps data-link-service-data-units into data-link-protocol-data-units on a one-to-one basis.

NOTE – More general mappings are for further study.

7.6.4.4 Data-link-connection splitting

This function performs splitting of one data-link-connection onto several physical-connections.

7.6.4.5 Delimiting and synchronization

These functions provide recognition of a sequence of physical-service-data-units (i.e. bits, see 7.7.3.2) transmitted over the physical-connection, as a data-link-protocol-data-unit.

NOTE – These functions are sometimes referred to as framing.

7.6.4.6 Sequence control

This function maintains the sequential order of data-link-service-data-units across a data-link-connection.

7.6.4.7 Error detection

This function detects transmission, format and operational errors occurring either on the physical-connection, or as a result of a malfunction of the correspondent data-link-entity.

7.6.4.8 Error recovery

This function attempts to recover from detected transmission, format and operational errors and notifies the network-entities of errors which are unrecoverable.

7.6.4.9 Flow control

In connection-mode, each network-entity can dynamically control (up to the agreed maximum) the rate at which it receives data-link-service-data-units from a data-link-connection. This control may be reflected in the rate at which the Data Link Layer accepts data-link-service-data-units at the correspondent data-link-connection-endpoint. In connectionless-mode, there is service boundary flow control, but no peer flow control.

7.6.4.10 Identification and parameter exchange

This function performs data-link-entity identification and parameter exchange.

7.6.4.11 Reset

This function performs a data-link reset forcing the data-link-entity-invocation to a known state.

7.6.4.12 Control of data-circuit interconnection

This function conveys to network-entities the capability of controlling the interconnection of data-circuits within the Physical Layer.

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NOTE – This function is used in particular when a physical-connection is established/released across a circuit-switched subnetwork by relaying within an intermediate system between data-circuits. These data-circuits are elements of the end-to-end path. A network-entity in the intermediate system makes the appropriate routing decisions as a function of the path requirements derived from the network signalling protocols.

7.6.4.13 Routing and Relaying

Some subnetworks, and particularly some configurations of local area networks, require that routing and relaying between individual local networks be performed in the data-link-layer.

7.6.4.14 Data Link Layer management

The Data Link Layer protocols deal with some management activities of the layer (such as activiation and error control). See clause 8 and ITU-T Rec. X.700 | ISO 7498-4 for the relationship with other management aspects.

7.7 Physical Layer

7.7.1 Definition

7.7.1.1 data-circuit: A communication path in the physical media for OSI among two or more physical-entities, together with the facilities necessary in the Physical Layer for the transmission of bits on it.

7.7.2 Purpose

The Physical Layer provides the mechanical, electrical, functional and procedural means to activate, maintain, and de-activate physical-connections for bit transmission between data-link-entities. A physical-connection may involve intermediate open systems, each relaying bit transmission within the Physical Layer. Physical Layer entities are interconnected by means of a physical medium.

7.7.3 Services provided to the Data Link Layer

7.7.3.1 The services provided by the Physical Layer are determined by the characteristics of the underlying medium and are too diverse to allow categorization into connection-mode and connectionless-mode.

7.7.3.2 The services or elements of services are provided by the Physical Layer:

a) physical-connections;

b) physical-service-data-units;

c) physical-connection-endpoints;

d) data-circuit identification;

e) sequencing;

f) fault condition notification; and

g) quality of service parameters.

7.7.3.3 Physical-connections

7.7.3.3.1 The Physical Layer provides for the transparent transmission of bit streams between data-link-entities across physical-connections.

7.7.3.3.2 A data-circuit is a communication path in the physical media for OSI among two or more physical-entities, together with the facilities necessary in the Physical Layer for the transmission of bits on it.

7.7.3.3.3 A physical-connection may be provided by the interconnection of data-circuits using relaying functions in the Physical Layer. The provision of a physical-connection by such an assembly of data-circuits is illustrated in Figure 17.

7.7.3.3.4 The control of the interconnection of data-circuits is offered as a service to data-link-entities.

7.7.3.4 Physical-service-data-units

7.7.3.4.1 A physical-service-data-unit consists of one bit or a string of bits.

NOTE – Serial or parallel transmission can be accommodated by the design of the protocol within the Physical Layer.

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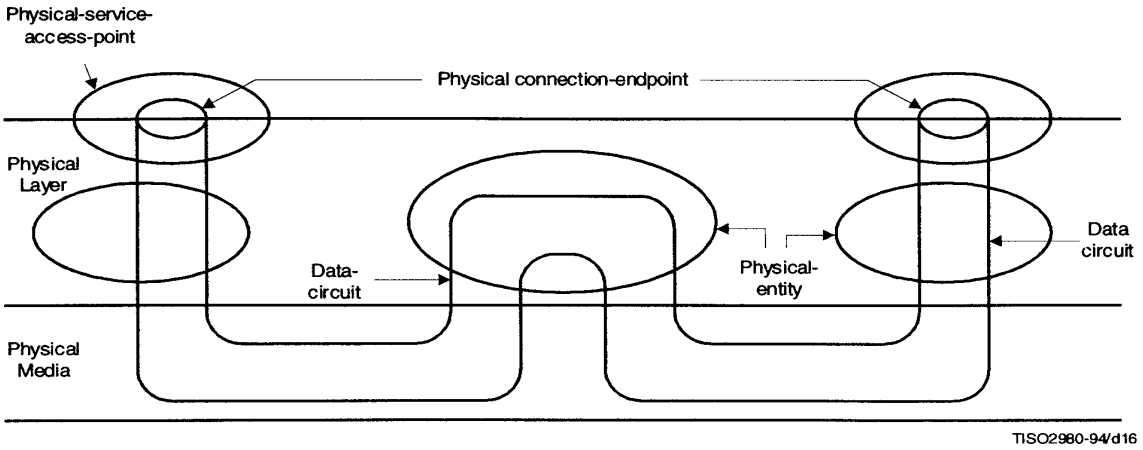


Figure 17 – Interconnection of data circuits within the Physical Layer

7.7.3.4.2 A physical-connection may allow duplex or half-duplex transmission of bit streams.

7.7.3.5 Physical-connection-endpoints

7.7.3.5.1 The Physical Layer provides physical-connection-endpoint-identifiers which may be used by a data-link-entity to identify physical-connection-endpoints.

7.7.3.5.2 A physical-connection will have two (point-to-point) or more (multi-endpoint) physical-connection-endpoints (see Figure 18).

7.7.3.6 Data-circuit identification

The Physical Layer provides identifiers which uniquely specify the data-circuits between two adjacent open systems.

NOTE – This identifier is used by network-entities in adjacent open systems to refer to data-circuits in their dialogue.

7.7.3.7 Sequencing

The Physical Layer delivers bits in the same order in which they were submitted.

7.7.3.8 Fault condition notification

Data-link-entities are notified of fault conditions detected within the Physical Layer.

7.7.3.9 Quality of service parameters

The quality of service of a physical-connection is derived from the data-circuits forming it. The quality of service can be characterized by:

a) error rate, where errors may arise from alteration, loss, creation, and other causes;

b) service availability;

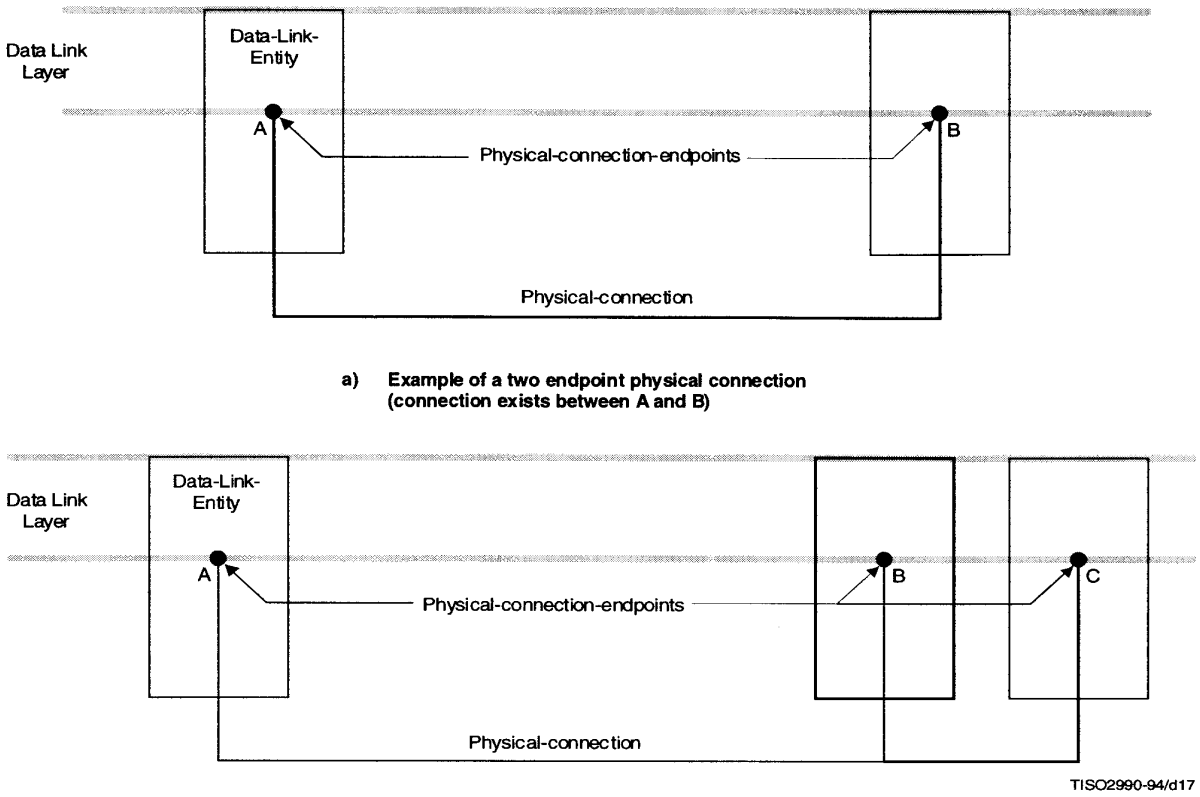
c) transmission rate; and

d) transit delay.

7.7.4 Functions within the Physical Layer

7.7.4.1 The functions of the Physical Layer are determined by the characteristics of the underlying medium and are too diverse to allow categorization into connection-mode and connectionless-mode.

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a) **Example of a two endpoint physical connection (connection exists between A and B)**

b) **Example of a multi-endpoint-physical-connection (connection exists between A, B and C)**

Figure 18 – Examples of physical connections

7.7.4.2 The functions provided by the Physical Layer are:

a) physical-connection activation and deactivation;

b) physical-service-data-unit transmission;

c) multiplexing; and

d) Physical Layer management.

7.7.4.3 Physical-connection activation and deactivation

These functions provide for the activation and deactivation of physical-connections between two data-link-entities upon request from the Data Link Layer. These include a relay function which provides for interconnection of data-circuits.

7.7.4.4 Physical-service-data-unit transmission

The transmission of physical-service-data-units (i.e. bits) may be synchronous or asynchronous. Optionally, the function of physical-service-data-unit transmission provides recognition of the protocol-data-unit corresponding to a mutually agreed sequence of physical-service-data-units that are being transmitted.

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7.7.4.5 Multiplexing

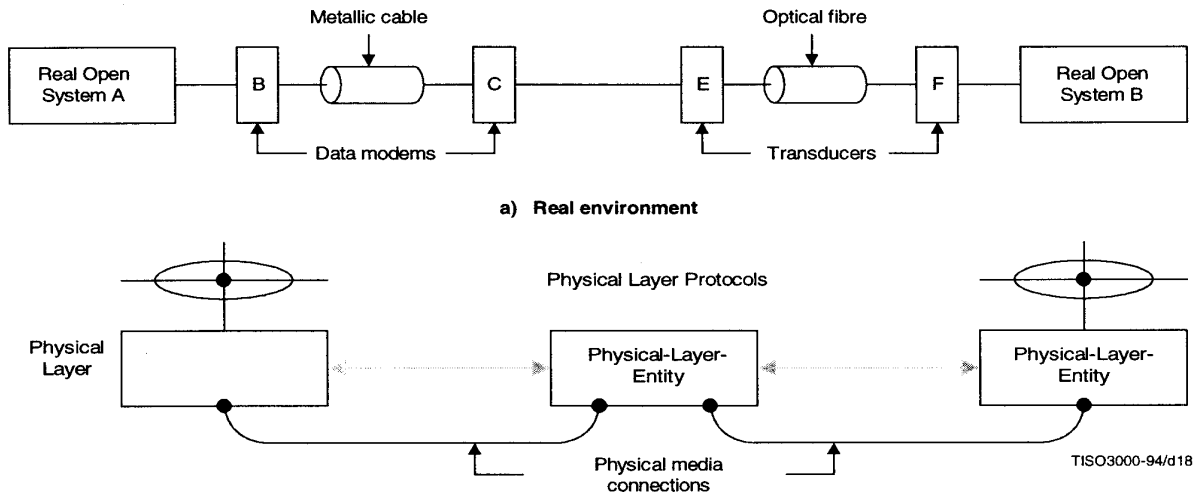
This function provides for two or more physical-connections to be carried on a single data-circuit. This function provides the recognition of the framing required to enable identification of the PhPDUs conveyed by the individual physical-connections over the single data-circuit. The multiplexing function is optional.

NOTE – A particular example of the use of multiplexing is offered when a transmission media is divided into data-circuits in support of the different data link protocols used in the signalling phase and in the data transfer phase when using circuit switched subnetworks. In such usage of multiplexing, flows of different nature are permanently assigned to different elements of the multiplex group.

7.7.4.6 Physical Layer management

7.7.4.6.1 The Physical Layer protocols deal with some management activities of the layer (such as activation and error control). See clause 8 and ITU-T Rec. X.700 | ISO 7498-4 for the relationship with other management aspects.

NOTE – The above text deals with interconnection between open systems as illustrated in Figure 11. For open systems to communicate in the real environment, real physical connections should be made as, for example, in Figure 19 a). Their logical representation is as shown in Figure 19 b) and is called the physical media connection. The mechanical, electromagnetic and other media dependent characteristics of physical media connections are defined at the boundary between the Physical Layer and the physical media. Definitions of such characteristics are specified in other standards.



NOTE – The area of physical media connections in OSI requires further study.

Figure 19 – Examples of interconnection

8 Management aspects of OSI

8.1 Definitions

8.1.1 application management: Functions in the Application Layer (see 6.1) related to the management of OSI application-processes.

8.1.2 application management application-entity: An application-entity which executes application-management functions.

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8.1.3 OSI resources: Data processing and data communication resources which are of concern to OSI.

8.1.4 systems management: Functions in the Application Layer related to the management of various OSI resources and their status across all layers of the OSI architecture.

8.1.5 systems management application-entity: An application-entity for the purposes of systems-management communications.

8.1.6 layer management: Functions related to the management of the (N)-layer partly performed in the (N)-layer itself according to the (N)-protocol of the layer (activities such as activation and error control) and partly performed as a subset of systems-management.

8.2 Introduction

8.2.1 Within the OSI Reference Model, there is a need to recognize the special problems of initiating, terminating, and monitoring activities and assisting in their harmonious operations, as well as handling abnormal conditions. These have been collectively considered as the management aspects of the OSI architecture. These concepts are essential to the operation of the interconnected open systems.

8.2.2 The management activities which are of concern are those which imply actual exchanges of information between open systems. Only the protocols needed to conduct such exchanges are candidates for standardization within the OSIE.

8.2.3 This clause describes key concepts relevant to the management aspects, including the different categories of management activities and the positioning of such activities within the OSI Reference Model.

8.2.4 Systems and layer management provide the initialization action to establish support for connectionless-mode services between systems.

8.2.5 Management facilities may be provided to allow characteristics of the nature, quality and type of connectionless-mode service provided by a layer to be conveyed to the next higher layer prior to the invocation of that service. These facilities may provide this information either prior to any invocation of the service or at any time during a period when it is available.

8.3 Categories of management activities

8.3.1 Introduction

8.3.1.1 Only those management activities which imply actual exchanges of information between remote management entities are pertinent to the OSI architecture. Other management activities local to particular open systems are outside its scope.

8.3.1.2 Similarly, not all resources are pertinent to OSI. This International Standard considers only OSI resources, i.e. those data processing and data communication resources which are of concern to OSI.

8.3.1.3 The following categories of management activities are identified:

a) application management;

b) systems management; and

c) layer management.

8.3.2 Application-management

8.3.2.1 Application-management relates to the management of OSI application-processes. The following list is typical of activities which fall into this category but it is not exhaustive:

a) initialization of parameters representing application-processes;

b) initiation, maintenance, and termination of application-processes;

c) allocation and de-allocation of OSI resources to application-processes;

d) detection and prevention of OSI resource interference and deadlock;

e) integrity and commitment control;

f) security control; and

g) checkpointing and recovery control.

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8.3.2.2 The protocols for application-management reside within the Application Layer, and are handled by application-management-application-entities.

8.3.3 Systems-management

8.3.3.1 Systems-management relates to the management of OSI resources and their status across all layers of the OSI Reference Model. The following list is typical of activities which fall into this category but it is not exhaustive:

a) activation/deactivation management which includes:
   1) activation, maintenance, and termination of OSI resources distributed in open systems, including physical media for OSI:
   2) some program loading functions;
   3) establishment/maintenance/ release of connections between management entities; and
   4) open systems parameter initialization/modification;

b) monitoring which includes:
   1) reporting status or status changes; and
   2) reporting statistics; and

c) error control which includes:
   1) error detection and some of the diagnostic functions; and
   2) reconfiguration and restart.

8.3.3.2 The protocols for systems-management reside in the application-layer, and are handled by systems-management-application-entities.

8.3.4 Layer-management

8.3.4.1 There are two aspects of layer-management. One of these is concerned with layer activities such as activation and error control. This aspect is implemented by the layer protocol to which it applies.

8.3.4.2 The other aspect of layer-management is a subset of systems-management. The protocols for these activities reside within the Application Layer and are handled by systems-management-application-entities.

8.4 Principles for positioning management functions

Several principles are important in positioning management functions in the Reference Model of Open Systems Interconnection. They include the following:[5)]

a) both centralization and decentralization of management functions are allowed. Thus, the OSI Reference Model does not dictate any particular fashion or degree of centralization of such functions. This principle calls for a structure in which each open system is allowed to include any (subset of) systems-management functions and each subsystem is allowed to include any (subset of) layer-management functions;

b) if it is necessary, connections between management entities are established when an open system which has been operating in isolation from other open systems, becomes part of the OSIE.

9 Compliance and Consistency with this reference model

9.1 Definitions

9.1.1 consistency: A "referencing" ITU-T Recommendation I International Standard is said to be consistent with a "referenced" ITU-T Recommendation I International Standard if it does not alter their meanings.

9.1.2 compliance: A "referencing" ITU-T Recommendation I International Standard is said to comply with the applicable requirements of a "referenced" ITU-T Recommendation I International Standard if the following are true:

a) the "referenced" ITU-T Recommendation I International Standard specifies requirements (using the verb "shall") which are applicable to the type of ITU-T Recommendation I International Standard of which the "referencing" ITU-T Recommendation I International Standard is an instance;

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5) Other principles are for further study.

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b) the "referenced" ITU-T Recommendation | International Standard includes a compliance clause to clarify which requirements apply to the type of ITU-T Recommendation | International Standard of which the "referencing" ITU-T Recommendation | International Standard is an instance;

c) the "referencing" ITU-T Recommendation | International Standard contains a claim of compliance to the "referenced" ITU-T Recommendation | International Standard; or

d) it is possible by inspection of the "referencing" ITU-T Recommendation | International Standard to verify that the applicable requirements have been fulfilled.

9.2 Application of consistency and compliance requirements

9.2.1 Other modelling ITU-T Recommendations | International Standards which extend or refine this Basic Reference Model shall be consistent with this part of it.

9.2.2 Compliance and consistency with this Basic Reference Model is also applicable to ITU-T Recommendations, International standards and technical reports which describe or specify OSI functions. These ITU-T Recommendations, International standards and reports can be architecture documents, models, frameworks, service definitions, or protocol specifications.

9.2.3 Consistency

9.2.3.1 An architecture, a framework, a multilayer model, a single layer model, a service definition, or a protocol specification consistent with this Basic Reference Model and other modelling ITU-T Recommendations | International Standards which extend or refine this Basic Reference Model shall state:

"This architecture, multilayer model, single layer model, service description, or protocol specification:

a) follows the architectural principles and prescriptions of the OSI Basic Reference Model (ITU-T Rec. X.200 | ISO/IEC 7498-1);

b) uses the concepts established by the OSI Basic Reference Model (ITU-T Rec. X.200 | ISO/IEC 7498-1) with identical definitions and terminology."

9.2.4 Compliance

9.2.4.1 Compliance of an architecture, framework, or multilayer model

An architecture, a framework, or a multilayer model compliant with this Basic Reference Model and other modeling ITU-T Recommendations | International Standards associated with this Basic Reference Model which refine this Basic Reference Model shall state:

"This architecture, framework, or multilayer model is compliant with the OSI Basic Reference Model (ITU-T Rec. X.200 | ISO/IEC 7498-1) in that it describes operations and mechanisms which are assignable to layers as specified in the OSI Basic Reference Model."

9.2.4.2 Compliance of a single layer model

A single layer model compliant with this OSI Basic Reference Model shall state:

"This single layer standard is compliant with the OSI Basic Reference Model (ITU-T Rec. X.200 | ISO/IEC 7498-1) in that it describes operations and mechanisms which pertain to a particular layer as specified in the relevant subclause of clause 7 of the OSI Basic Reference Model."

9.2.4.3 Compliance of a service definition

A service definition compliant with OSI Basic Reference Model shall state:

"This service definition is compliant with the OSI Basic Reference Model (ITU-T Rec. X.200 | ISO/IEC 7498-1) in that it describes facilities which pertain to a particular layer as specified in the relevant subclause of clause 7 of the OSI Basic Reference Model."

9.2.4.4 Compliance of a protocol specification

A protocol specification compliant with the OSI Basic Reference Model shall state:

"This protocol specification is compliant with the OSI Basic Reference Model (ITU-T Rec. X.200 | ISO/IEC 7498-1) in that it describes functions which pertain to a particular layer as specified in the relevant subclause of clause 7 of the OSI Basic Reference Model."

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Annex A
Brief explanation of how the layers were chosen

(This annex does not form an integral part of this Recommendation | International Standard)

A.1 This annex provides elements giving additional information to this Recommendation | International Standard.

A.2 The following is a brief explanation of how the layers were chosen:

A.2.1 It is essential that the architecture permits usage of a realistic variety of physical media for interconnection with different control procedures (for example ITU-T Recs. V.24, V.25, etc.). Application of principles in 6.2 c), e) and h) leads to identification of a **Physical Layer** as the lowest layer in the architecture.

A.2.2 Some physical communication media (for example, telephone line) require specific techniques to be used in order to transmit data between systems despite a relatively high error rate (i.e. an error rate not acceptable for the great majority of applications). These specific techniques are used in data-link control procedures which have been studied and standardized for a number of years. It must also be recognized that new physical communication media (for example, fibre optics) will require different data-link control procedures. Application of principles in 6.2 c), e) and h) leads to identification of a **Data Link Layer** on top of the Physical Layer in the architecture.

A.2.3 In the open systems architecture, some open systems will act as the final destination of data, see clause 4. Some open systems may act only as intermediate nodes [(forwarding data to other systems) (see Figure 13)]. Application of principles in 6.2 c), e) and g) leads to identification of a **Network Layer** on top of the Data Link Layer. Network oriented protocols such as routing, for example, will be grouped in this layer. Thus, the Network Layer will provide a connection path (network-connection) between a pair transport-entities; including the case where intermediate nodes are involved, see Figure 12 (see also 7.5.4.2).

A.2.4 Control of data transportation from source end open system to destination end open system (which is not performed in intermediate nodes) is the last function to be performed in order to provide the totality of the transport-service. Thus, the upper layer in the transport-service part of the architecture is the **Transport Layer**, on top of the Network Layer. This Transport Layer relieves higher layer entities from any concern with the transportation of data between them.

A.2.5 There is a need to organize and synchronize dialogue, and to manage the exchange of data. Application of principles in 6.2 c) and d) leads to the identification of a **Session Layer** on top of the Transport Layer.

A.2.6 The remaining set of general interest functions are those related to representation and manipulation of structured data for the benefit of application programs. Application of principles in 6.2 c) and d) leads to identification of a **Presentation Layer** on top of the Session Layer.

A.2.7 Finally, there are applications consisting of application-processes which perform information processing. An aspect of these application-processes and the protocols by which they communicate comprise the **Application Layer** as the highest layer of the architecture.

A.3 The resulting architecture with seven layers, illustrated in Figure 11, obeys the principles in 6.2 a) and b).

A more detailed definition of each of the seven layers identified above is given in clause 7 of this Recommendation | International Standard, starting from the top with the Application Layer described in 7.1 down to the Physical Layer described in 7.7.

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Annex B
Alphabetical index to definitions

(This annex forms an integral part of this Recommendation | International Standard)

Term	Subclause	Page
abstract syntax	7.1.1.2	32
acknowledgement	5.8.1.16	17
(N)-address	5.4.1.1	13
(N)-address-mapping	5.4.1.3	13
application-entity	7.1.1.1	32
application-management	8.1.1	52
application-management-application-entity	8.1.2	52
application-process	4.1.4	2
application-process-invocation	4.1.7	2
application-process-type	4.1.8	2
(N)-association	5.3.1.1	9
blocking	5.8.1.11	17
centralized multi-endpoint-connection	5.8.1.2	16
compliance	9.1.2	54
concatenation	5.8.1.13	17
concrete syntax	7.2.1.1	33
(N)-connection	5.3.1.2	9
(N)-connection-endpoint	5.3.1.3	9
(N)-connection-endpoint-identifier	5.4.1.5	13
(N)-connection-endpoint-suffix	5.4.1.6	13
(N)-connection-mode-transmission	5.3.1.17	9
(N)-connectionless-mode-transmission	5.3.1.18	9
consistency	9.1.1	54
correspondent (N)-entities	5.3.1.5	9
data-circuit	7.7.1.1	49
(N)-data communication	5.3.1.13	9
(N)-data sink	5.3.1.8	9
(N)-data source	5.3.1.7	9
(N)-data transmission	5.3.1.9	9
deblocking	5.8.1.12	17
decentralized multi-endpoint-connection	5.8.1.3	16
demultiplexing	5.8.1.5	17
duplex mode	7.3.1.2	34
(N)-duplex transmission	5.3.1.10	9

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Term	Subclause	Page
(N)-entity	5.2.1.11	6
(N)-entity-invocation	5.2.1.12	6
(N)-entity-type	5.2.1.10	6
(N)-entity-title	5.4.1.10	13
expedited (N)-service-data-unit	5.6.1.6	15
(N)-expedited-data-unit	5.6.1.6	15
(N)-facility	5.2.1.6	6
flow control	5.8.1.8	17
(N)-function	5.2.1.7	6
half duplex mode	7.3.1.3	34
(N)-half-duplex transmission	5.3.1.11	9
(N)-layer	5.2.1.2	6
layer-management	8.1.6	53
local system environment (LSE)	4.1.6	2
multi-connection-endpoint-identifier	5.4.1.7	13
multi-endpoint-connection	5.3.1.4	9
multiplexing	5.8.1.4	16
(N)-one-way communication	5.3.1.16	9
open system	4.1.3	2
open system interconnection environment (OSIE)	4.1.5	2
OSI end system	6.5.1.1	31
OSI-(N)-relay system	6.5.1.2	31
OSI resources	8.1.3	53
peer-(N)-entities	5.2.1.3	6
presentation context	7.2.1.3	33
(N)-protocol	5.2.1.9	6
(N)-protocol-connection-identifier	5.4.1.9	13
(N)-protocol-control-information (PCI)	5.6.1.1	15
(N)-protocol-data-unit (PDU)	5.6.1.3	15
(N)-protocol-identifier	5.8.1.1	16
(N)-protocol-version-identifier	5.8.1.18	17
real system	4.1.1	2
real open system	4.1.2	2
real subnetwork	7.5.1.1	41
reassembling	5.8.1.10	17
recombining	5.8.1.7	17
(N)-relay	5.3.1.6	9
reset	5.8.1.17	17

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Term	Subclause	Page
routing	5.4.1.4	13
segmenting	5.8.1.9	17
separation	5.8.1.14	17
sequencing	5.8.1.15	17
(N)-service	5.2.1.5	6
(N)-service-access-point (SAP)	5.2.1.8	6
(N)-service-access-point-address	5.4.1.2	13
(N)-service-connection-identifier	5.4.1.8	13
(N)-service-data-unit (SDU)	5.6.1.4	15
session-connection synchronization	7.3.1.4	35
(N)-simplex transmission	5.3.1.12	9
splitting	5.8.1.6	17
sublayer	5.2.1.4	6
subnetwork	7.5.1.2	41
subnetwork-connection	7.5.1.3	41
(N)-subsystem	5.2.1.1	6
systems-management	8.1.4	53
systems-management-application-entity	8.1.5	53
token management	7.3.1.1	34
transfer syntax	7.2.1.2	33
(N)-two-way alternate communication	5.3.1.15	9
(N)-two-way simultaneous communication	5.3.1.14	9
N)-user-data	5.6.1.2	15

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ICS 35.100.00

Descriptors: data processing, information interchange, network interconnection, open systems interconnection, reference models.

Price based on 59 pages

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:

200233
435 Guiping Road, Shanghai, China
SHANGHAI PATENT & TRADEMARK LAW OFFICE, LLC

171594 1PCW0 DZ_X236

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

	Date of mailing *(day/month/year)* 06. Dec. 2017 (06. 12. 2017)
Applicant's or agent's file reference 171594PCW0	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/CN2017/075961	International filing date *(day/month/year)* 08. Mar. 2017 (08. 03. 2017)
Applicant CREDO TECHNOLOGY GROUP LTD.	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

Filing of amendments and statement under Article 19:

The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20,Switzerland, Facsimile No.:+41 22 338 82 70

For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 – 9.011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:
   ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.
   ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established.

Following the expiration of 30 months from the priority date, these comments will also be made available to the public.

Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later);otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months.

For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide*, National Chapters.

STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA(ISA/CN) 6,Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088 Facsimile No. (86-10) 62019451	Authorized officer CHEN, Xi Telephone No.: (86-10) 6 [illegible]27

Form PCT/ISA/220 (July 2009)

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NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under Article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the *PCT Applicant's Guide*.

In these Notes, "Article," "Rule" and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions, respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report and the written opinion of the International Searching Authority, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only (see *PCT Applicant's Guide*).

The attention of the applicant is drawn to the fact that amendments to the claims under Article 19 are not allowed where the International Searching Authority has declared, under Article 17(2), that no international search report would be established (see *PCT Applicant's Guide*, paragraph 296).

What parts of the international application may be amended ?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Preliminary Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When ? Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments ?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How ? Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet or sheets containing a complete set of claims in replacement of all the claims previously filed must be submitted.

Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively in Arabic numerals (Section 205(a)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments ?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

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The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

(i) the claim is unchanged;
(ii) the claim is cancelled;
(iii) the claim is new;
(iv) the claim replaces one or more claims as filed;
(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
   "Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."
2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
   "Claims 1 to 15 replaced by amended claims 1 to 11."
3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
   "Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
   "Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."
4. [Where various kinds of amendments are made]:
   "Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under Article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international application is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments and any accompanying statement, under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the time of filing the amendments (and any statement) with the International Bureau, also file with the International Preliminary Examining Authority a copy of such amendments (and of any statement) and, where required, a translation of such amendments for the procedure before that Authority (see Rules 55.3(a) and 62.2, first sentence). For further information, see the Notes to the demand form (PCT/IPEA/401).

If a demand for international preliminary examination is made, the written opinion of the International Searching Authority will, except in certain cases where the International Preliminary Examining Authority did not act as International Searching Authority and where it has notified the International Bureau under Rule 66.1*bis*(b), be considered to be a written opinion of the International Preliminary Examining Authority. If a demand is made, the applicant may submit to the International Preliminary Examining Authority a reply to the written opinion together, where appropriate, with amendments before the expiration of 3 months from the date of mailing of FormPCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later (Rule 43*bis*.1(c)).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see the *PCT Applicant's Guide*, National Chapters.

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201712111134840B7

PATENT COOPERATION TREATY

PCT

171594 1PCT0 DZ_X236

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
171594PCT0			
International application No.	International filing date	(Earliest)Priority date	
PCT/CN2017/075961	*(day/month/year)*	*(day/month/year)*	
	08 Mar. 2017(08. 03. 2017)		

Applicant

CREDO TECHNOLOGY GROUP LTD.

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of:

☒ the international application in the language in which it was filed

☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6bis(a)).

c. ☐ With regard to any **nucleotide and /or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (see Box No. II)

3. ☐ **Unity of invention is lacking** (see Box No. III)

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box IV.

The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,

a. The figure of the **drawings** to be published with the abstract is Figure No.3

☐ as suggested by the applicant

☒ as selected by this Authority, because the applicant failed to suggest a figure

☐ as selected by this Authority, because this figure better characterizes the invention

b. ☐ none of the figures is to be published with the abstract

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/075961

A. CLASSIFICATION OF SUBJECT MATTER

H04L 12/24 (2006.01) i

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: H04L

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
CNPAT, CNKI, WPI, EPODOC, IEEE: 802.3, ethernet, extend+, PMA, physical medium attachment, auto w negotiation, training, data, phase, back w channel, modulat+, convey+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014140833A1 (LUSTED, Kent C. et al.) 29 May 2014(29.05.2014) abstract, description, paragraphs [0042]-[0059], [0098]-[0104], [0119]-[0122] and figure 1	1-23
X	US 2014086264A1 (LUSTED, Kent C. et al.) 27 Mar.2014(27.03.2014) abstract, description, paragraphs [0041]-[0054], [0099]-[0107], [0119]-[0122] and figure 1	1-23
X	US 2013343400A1 (LUSTED, Kent C. et al.) 26 Dec.2013(26.12.2013) abstract, description, paragraphs [0036]-[0049], [0082] and figure 1	1-23
A	CN 1941649A (BROADCOM CORPORATION) 04 Apr.2007(04.04.2007) the whole document	1-23
A	LAN/MAN Standards Committee of the IEEE Computer Society IEEE Standard for Ethernet IEEE Std 802.3™-2015 03 Sep.2015(03.09.2015) the whole document	1-23

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

Form PCT/ISA /210 (2 sheet) (July 2009)

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/075961

* 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 application or patent 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
08 Nov. 2017 (08. 11. 2017)	06 Dec. 2017 (06. 12. 2017)
Name and mailing address of the ISA/CN STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China Facsimile No.(86-10)62019451	Authorized officer CHEN, Xiaowei Telephone No.: (86-10) 61648277

Form PCT/ISA /210 (3 sheet) (July 2009)

Marvell Semiconductor, Inc. - Ex. 1002, Page 000152

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2017/075961

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
US2014146833A1	29.05.2014	JP2014107869A	09.06.2014
		DE202013105453U1	06.11.2014
US2014086264A1	27.03.2014	JP2014068345A	17.04.2014
		DE202013104344U1	20.02.2014
US2013343400A1	26.12.2013	WO2013191912A1	27.12.2013
		CN104322014A	28.01.2015
		CA2908681A1	27.12.2013
CN1941649A	04.04.2007	EP1770912A1	04.04.2007
		US2013243011A1	19.09.2013
		TW200729833A	01.08.2007
		US2007076722A1	05.04.2007
		US2011205934A1	25.08.2011
		DE602006003500E	18.12.2008

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PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:

200233

435 Guiping Road, Shanghai, China

SHANGHAI PATENT & TRADEMARK LAW OFFICE, LLC

171594 1PCW0 DZ_X236

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43 *bis*.1)

		Date of mailing(*day/month/year*) 06. Dec. 2017 (06. 12. 2017)
Applicant's or agent's file reference 171594PCW0		**FOR FURTHER ACTION** See paragraph 2 below
International application No. PCT/CN2017/075961	International filing date(*day/month/year*) 08. Mar. 2017 (08. 03. 2017)	Priority date (*day/month/year*)
International Patent Classification (IPC) or both national classification and IPC H04L 12/24 (2006. 01) i		
Applicant CREDO TECHNOLOGY GROUP LTD.		

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA/CN	Date of completion of this opinion	Authorized officer
STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	24. Nov. 2017 (24. 11. 2017)	**CHEN,Xiaowei** Telephone No. (86-10)61648377

Form PCT/ISA/237(cover sheet)(July 2009)

Marvell Semiconductor, Inc. - Ex. 1002, Page 000154

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

international application No.
PCT/CN2017/075961

005

Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:

☒ the international application in the language in which it was filed.

☐ a translation of the international application into_____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91(Rule 43bis.1(a))

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application ,this opinion has been established on the basis of a sequence listing filed or furnished :

a. (means):

☐ on paper

☐ in electronic form

b. (time):

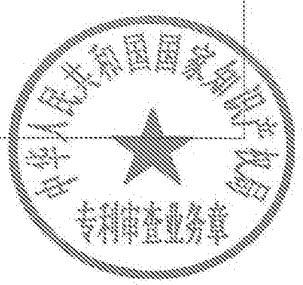
☐ in the international application as filed

☐ together with the international application in electronic form

☐ subsequently to this Authority for the purposes of search

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:



Marvell Semiconductor, Inc. - Ex. 1002, Page 000155

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/CN2017/075961

Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement:

Novelty (N)	Claims 1-23	YES
	Claims None	NO
Inventive step (IS)	Claims None	YES
	Claims 1-23	NO
Industrial applicability (IA)	Claims 1-23	YES
	Claims None	NO

2. Citations and explanations

The reasoning with claim 14 is based on the prediction in Box No. VIII.

(1) Reference is made to the following document:

D1: US2014146833A1

(2) Novelty and Inventive step

(2.1) D1 discloses a method for implementing PMA alignment and rapid transition from a link training mode to a data mode (see abstract, description, paragraphs [0042]-[0059], [0098]-[0104], [0119]-[0122] and figure 1): The PHY structure of one embodiment of a 100 GBASE-KP4 link is illustrated in FIG. 1. The PHY is responsible for dealing with details of operation of the signals on a particular link between two link partners, depicted by components A and B. The physical connectivity of each interconnect link is made up of four differential pairs of signals 100, comprising lanes 0-3 in each direction. Each port supports a link pair consisting of two uni-directional links to complete the connection between two components. Each port comprises a Transmit (Tx) link interface and a Receive (Rx) link interface. The 100 GBASE-KP4 link is established using the following sequence: (1) Auto-negotiate capabilities to link partner; (2) Send out training sequence to tune PHY for the channel's characteristics; (3) Count down to data mode and Send out idle symbols. The training frames are transmitted using Physical Media Attachment (PMA) framing logic. Component A has a Tx port102 that is connected to Component B Rx port104. Meanwhile, Component B has a Tx port104 that is connected to Component B Rx port108. The 100 GBASE-KP4 PHY uses PAM4 signal to send and receive data across the channel. The following information is implicitly disclosed based on the disclosure of D1: (claim 1) an Ethernet link extender that comprises: a first and a second PMA circuit having a transmitter and a receiver, and their communication manner; (claim 11) an Ethernet link extension method that comprises: in a first communications phase for auto-negotiation and its details; and a subsequent communications phase for training; and (claim 21) an Ethernet link extension method that comprises, in a first communications phase for

Marvell Semiconductor, Inc. - Ex. 1002, Page 000156

auto-negotiation: coupling a transmitter of a second PMA circuit to a receiver of a first PMA circuit to retransmit channel signal waveforms received from a first node; coupling a transmitter of the first PMA circuit to a receiver of the second PMA circuit to retransmit channel signal waveforms received from a second node; and a subsequent frame-forwarding phase.

(2.2) The subject matter of claim 1 differs from D1 in that: (1) the first and second PMA circuits each including a respective training controller that, during the training phase, generates training frames for transmission by the transmitter of the respective PMA circuit based in part on back-channel information and training status information from the receiver of the respective PMA circuit.

The subject matter of claim 11 differs from D1 in that: said (1).

The subject matter of claim 21 differs from D1 in that: (2) the auto-negotiation phase includes: monitoring spectra of the channel signal waveforms received from at least one of the first and second nodes to detect an end of the auto-negotiation phase; (3) the details of frame-forwarding phase.

Therefore, the subject matter of claims 1, 11 and 21 is novel in the sense of PCT Article 33(2).

As to the above differences, D1 discloses: data mode, the 100 GBASE-KP4 PHY uses a 4-level pulse amplitude modulation PAM4 signal to send and receive data across the channel. Hence, difference (3) is a normal design option known to the person skilled in the art. And differences (1), (2) are also normal design option known to the person skilled in the art. Therefore, the subject matter of claims 1, 11, 21 does not involve an inventive step in the sense of PCT Article 33(3).

(2.3) Claims 2-10, 12-20, 22-23 are dependent claims. Part of the additional features are disclosed by D1 (see the same reference), the other part of the additional features are common technical means to the person skilled in the art. Therefore, the subject matter of claims 2-10, 12-20, 22-23 is novel in the sense of PCT Article 33(2), but does not involve an inventive step in the sense of PCT Article 33(3).

(3) Industrial applicability

Claims 1-23 meet the requirements of PCT Article 33(4).

Marvell Semiconductor, Inc. - Ex. 1002, Page 000157

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

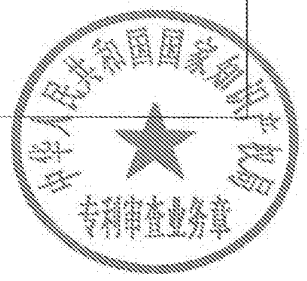
International application No.
PCT/CN2017/076961

125

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claim supported by the description, are made:

The subject matter of dependent claim 14 is different from the subject matter of independent claim 1. Therefore, claim 14 is not clear in the sense of PCT Article 6. The reasoning with claim 14 in Box No.V is based on the following prediction: the subject matter of claim 14 is "The method claim 11".



Marvell Semiconductor, Inc. - Ex. 1002, Page 000158

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/487,045	04/13/2017	Junqing Sun	CRDO-018A	4720

70075 7590 01/24/2018

Iselin Law PLLC (SC)
P O BOX 1906
CYPRESS, TX 77410-1906

EXAMINER
TAYONG, HELENE E

ART UNIT	PAPER NUMBER
2631	

MAIL DATE	DELIVERY MODE
01/24/2018	PAPER

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.

Office Action Summary	Application No. 15/487,045	Applicant(s) SUN ET AL.	
	Examiner HELENE TAYONG	Art Unit 2631	AIA (First Inventor to File) Status Yes

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

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 2 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 *04/13/17*.

☐ 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) *1-20* is/are pending in the application.

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

6)☒ Claim(s) *1-20* is/are allowed.

7)☐ Claim(s) _____ 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 *04/13/17* 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: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

2. This application is in condition for allowance except for the following formal matters:

Drawings

3. The drawings are objected to under 37 CFR 1.83(a). The drawings must show every feature of the invention specified in the claims. Therefore, **the *alignment marker detection module that detects alignment markers in each lane of the multi-lane receive data stream*** must be shown or the feature(s) canceled from the claim(s). No new matter should be entered.

Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as "amended." If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an

application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Claim Objections

4. Claims 8 and 18 are objected to because of the following informalities: In claims 8 and 18 line 2, change, "or FEC encoding" to - - -or forward error correction (FEC) encoding- - -. Appropriate correction is required.

CLAIM INTERPRETATION

5. The following is a quotation of 35 U.S.C. 112(f):

> (f) Element in Claim for a Combination. – An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

The following is a quotation of pre-AIA 35 U.S.C. 112, sixth paragraph:

> An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.

6. The claims in this application are given their broadest reasonable interpretation using the plain meaning of the claim language in light of the specification as it would be understood by one of ordinary skill in the art. The broadest reasonable interpretation of a claim element (also commonly referred to as a claim limitation) is

limited by the description in the specification when 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, is invoked.

As explained in MPEP § 2181, subsection I, claim limitations that meet the following three-prong test will be interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph:

(A) the claim limitation uses the term "means" or "step" or a term used as a substitute for "means" that is a generic placeholder (also called a nonce term or a non-structural term having no specific structural meaning) for performing the claimed function;

(B) the term "means" or "step" or the generic placeholder is modified by functional language, typically, but not always linked by the transition word "for" (e.g., "means for") or another linking word or phrase, such as "configured to" or "so that"; and

(C) the term "means" or "step" or the generic placeholder is not modified by sufficient structure, material, or acts for performing the claimed function.

Use of the word "means" (or "step") in a claim with functional language creates a rebuttable presumption that the claim limitation is to be treated in accordance with 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph. The presumption that the claim limitation is interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, is rebutted when the claim limitation recites sufficient structure, material, or acts to entirely perform the recited function.

Absence of the word "means" (or "step") in a claim creates a rebuttable presumption that the claim limitation is not to be treated in accordance with 35 U.S.C. 112(f) or pre-

AIA 35 U.S.C. 112, sixth paragraph. The presumption that the claim limitation is not interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, is rebutted when the claim limitation recites function without reciting sufficient structure, material or acts to entirely perform the recited function.

Claim limitations in this application that use the word "means" (or "step") are being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, except as otherwise indicated in an Office action. Conversely, claim limitations in this application that do not use the word "means" (or "step") are not being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, except as otherwise indicated in an Office action.

7. This application includes one or more claim limitations that do not use the word "means," but are nonetheless being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, because the claim limitation(s) uses a generic placeholder that is coupled with functional language without reciting sufficient structure to perform the recited function and the generic placeholder is not preceded by a structural modifier. Such claim limitation(s) is/are: **[adaptation module]**, **[alignment marker detection module]**, **[extraction module]** and **[alignment marker insertion module]** in claim [11].

Because this/these claim limitation(s) is/are being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, it/they is/are being interpreted to cover the corresponding structure described in the specification as performing the claimed function, and equivalents thereof.

If applicant does not intend to have this/these limitation(s) interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph, applicant may: (1) amend the claim limitation(s) to avoid it/them being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph (e.g., by reciting sufficient structure to perform the claimed function); or (2) present a sufficient showing that the claim limitation(s) recite(s) sufficient structure to perform the claimed function so as to avoid it/them being interpreted under 35 U.S.C. 112(f) or pre-AIA 35 U.S.C. 112, sixth paragraph.

Allowable Subject Matter

8. Claims 1-20 are allowed.

9. The following is an examiner's statement of reasons for allowance: the prior arts made of record fail to teach or suggest or make obvious in combination, the arrangement that *detecting alignment markers in each lane of the multi-lane receive data stream; extracting local pre-equalizer adaptation information from the multi-lane receive data stream, said adaptation information being included in, or proximate to, the alignment markers in at least one lane of the multi-lane receive data stream; using the local pre-equalizer adaptation information to adjust one or more coefficients of a local pre-equalization filter; periodically inserting an alignment marker in each lane of a multi-lane transmit data stream, wherein the remote pre-equalizer adaption information is included in, or inserted proximate to, the alignment markers in at least one lane of the multi-lane transmit data stream; transforming each lane of the multi-lane transmit data stream into a transmit signal, wherein said transforming includes modulating and further*

includes applying the local preequalization filter; and transmitting the transmit signals on different transmit channels.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Prosecution on the merits is closed in accordance with the practice under *Ex parte Quayle*, 25 USPQ 74, 453 O.G. 213, (Comm'r Pat. 1935).

A shortened statutory period for reply to this action is set to expire **TWO MONTHS** from the mailing date of this letter.

Conclusion

10. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Kuan et al (US 9385859B2) discloses a multi-lane receiver for concurrently receiving plural bit streams clocked according to a common clock source, the multi-lane receiver.

Akhter et al (US 8842721) discloses adjusting equalizer coefficients based on 8B10B error counts and an error threshold, a receiver may be dynamically adjusted. By adjusting transmitter pre-emphasis based on 8B10B error counts and an error threshold, a transmitter may be dynamically adjusted. Both the transmitter and receiver

may be adjusted dynamically based on 8B10B error counts and different error thresholds

Any inquiry concerning this communication or earlier communications from the examiner should be directed to HELENE TAYONG whose telephone number is (571)270-1675. The examiner can normally be reached on Monday-Friday 8:00 am to 5:30 pm EST.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Liu Shuwang can be reached on 571-272-3036. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may 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). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/HELENE TAYONG/
Primary Examiner, Art Unit 2631
January 22, 2018

Notice of References Cited	Application/Control No. 15/487,045	Applicant(s)/Patent Under Reexamination SUN ET AL.	
	Examiner HELENE TAYONG	Art Unit 2631	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-2016/0337114 A1	11-2016	BADEN; Eric	H04J3/0697	1/1
*	B	US-2015/0003505 A1	01-2015	Lusted; Kent C.	H04L25/4917	375/224
*	C	US-9,385,859 B2	07-2016	Kuan; Chi-Kung	H04L7/0087	1/1
	D	US-				
	E	US-				
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC 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.

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

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		
	Application Number	15/487,045
	371 (c) Date	2017-04-13
	Applicant	CREDO TECHNOLOGY GROUP LIMITED
	Art Unit	2631
	Examiner Name	Shuwang Liu
	Attorney Docket Number	CRDO-018A

U.S. PATENTS				
Examiner Initial*	**Patent Number**	**Issue Date**	**Name of Patentee or Applicant of cited Document**	**Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear**

U.S. PATENT APPLICATION PUBLICATIONS				
Examiner Initial*	**Publication Number**	**Publication Date**	**Name of Patentee or Applicant of cited Document**	**Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear**

FOREIGN PATENT DOCUMENTS					
Examiner Initial*	**Foreign Document Number[3]**	**Country Code[2]**	**Publication Date**	**Name of Patentee or Applicant of cited Document**	**T[5]**

NON-PATENT LITERATURE DOCUMENTS			
Examiner Initials*	**Cite No[1]**	**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, page(s), volume-issue number(s), publisher, city and/or country where published.**	**T[2]**
		"Physical Coding Sublayer (PCS) for 64B/66B, type 50GBASE-R," Draft Amendment to IEEE Std 802.3-2015, February 3, 2017, pp. 132-141, 10 pgs	
		"Physical Medium Attachment (PMA) sublayer, Physical Medium Dependent (PMD) sublayer, and baseband medium, type 100GBASE-KP4," IEEE Standard for Ethernet, Section Six, pp. 481-519, 39 pgs	
		"Physical Medium Dependent (PMD) sublayer and baseband medium, type 50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4," Draft Amendment to IEEE Std 802.3-2015, February 3, 2017, pp. 184-215, 32 pgs	
		"Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 50GBASE-R PHYs," Draft Amendment to IEEE Std 802.3-2015, February 3, 2017, pp. 142-159, 18 pgs	

EXAMINER SIGNATURE: /HELENE E TAYONG/ **DATE CONSIDERED:** 01/22/2018

*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.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /H.E.T/

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

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

Application Number	15/487,045
371 (c) Date	2017-04-13
Applicant	CREDO TECHNOLOGY GROUP LIMITED
Art Unit	2631
Examiner Name	Shuwang Liu
Attorney Docket Number	CRDO-018A

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.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ None

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	/Louis H. Iselin/	Date (YYYY-MM-DD)	2017-06-20
Name/Print	Louis H Iselin	Registration Number	42,684

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91. Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 100GBASE-R PHYs

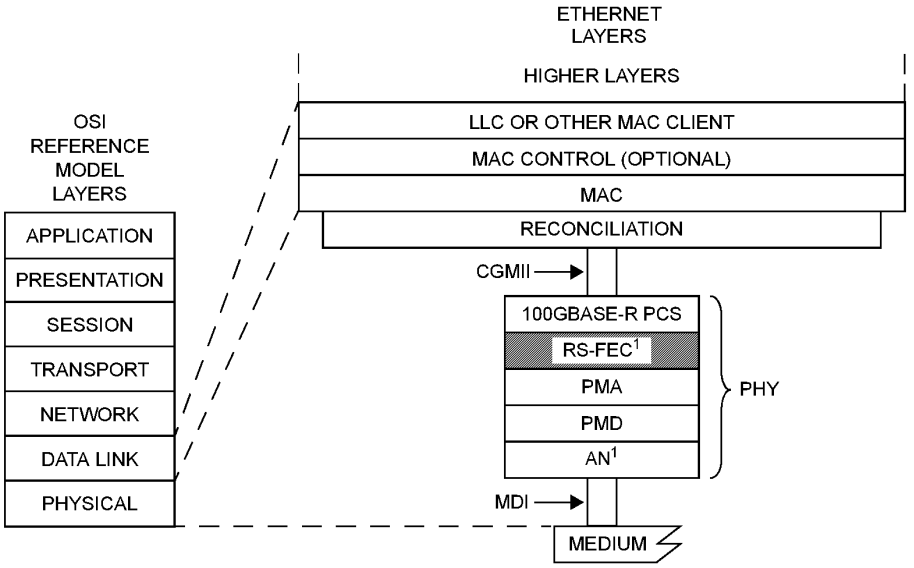
91.1 Overview

91.1.1 Scope

This clause specifies a Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 100GBASE-R PHYs. Annex 91A provides examples of RS-FEC codewords constructed with the method specified in this clause.

91.1.2 Position of RS-FEC in the 100GBASE-R sublayers

Figure 91–1 shows the relationship of the RS-FEC sublayer to the ISO/IEC Open System Interconnection (OSI) reference model.



AN = AUTO-NEGOTATION
CGMII = 100 Gb/s MEDIA INDEPENDENT INTERFACE
LLC = LOGICAL LINK CONTROL
MAC = MEDIA ACCESS CONTROL
MDI = MEDIUM DEPENDENT INTERFACE
PCS = PHYSICAL CODING SUBLAYER
PHY = PHYSICAL LAYER DEVICE
PMA = PHYSICAL MEDIUM ATTACHMENT
PMD = PHYSICAL MEDIUM DEPENDENT
RS-FEC = REED-SOLOMON FORWARD ERROR CORRECTION

NOTE 1—CONDITIONAL BASED ON PHY TYPE

Figure 91–1—RS-FEC relationship to the ISO/IEC Open Systems Interconnection (OSI) reference model and the IEEE 802.3 Ethernet model

91.2 FEC service interface

This subclause specifies the services provided by the RS-FEC sublayer. The service interface is described in an abstract manner and does not imply any particular implementation.

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The FEC service interface is provided to allow the PCS to transfer information to and from the RS-FEC. The PCS may be connected to the RS-FEC using an optional instantiation of the PMA service interface (refer to Annex 83A or Annex 83D) in which case a PMA is the client of the FEC service interface.

The FEC service interface is an instance of the inter-sublayer service interface defined in 80.3. The FEC service interface primitives are summarized as follows:

FEC:IS_UNITDATA_*i*.request
FEC:IS_UNITDATA_*i*.indication
FEC:IS_SIGNAL.indication

The RS-FEC operates on 20 parallel bit streams, hence $i = 0$ to 19. The PCS (or PMA) continuously sends 20 parallel bit streams to the RS-FEC, one per lane, each at a nominal signaling rate of 5.15625 GBd. The RS-FEC continuously sends 20 parallel bit streams to the PCS (or PMA), one per lane, each at a nominal signaling rate of 5.15625 GBd

The SIGNAL_OK parameter of the FEC:IS_SIGNAL.indication primitive can take one of two values: OK or FAIL. The value is set to OK when the FEC receive function has identified codeword boundaries as indicated by fec_align_status equal to true. That value is set to FAIL when the FEC receive function is unable to reliably establish codeword boundaries as indicated by fec_align_status equal to false. When SIGNAL_OK is FAIL, the rx_bit parameters of the FEC:IS_UNITDATA_*i*.indication primitives are undefined.

If the optional EEE deep sleep capability is supported, then the FEC service interface includes four additional primitives as follows:

FEC:IS_TX_MODE.request
FEC:IS_RX_MODE.request
FEC:IS_RX_TX_MODE.indication
FEC:IS_ENERGY_DETECT.indication

When the tx_mode parameter of the FEC:IS_TX_MODE.request primitive is QUIET or ALERT, the RS-FEC sublayer may disable transmit functional blocks to conserve energy. Otherwise the RS-FEC transmit function operates normally. The value of tx_mode is passed to the client sublayer via the PMA:IS_TX_MODE.request primitive.

When the rx_mode parameter of the FEC:IS_RX_MODE.request primitive is QUIET, the RS-FEC sublayer may disable receive functional blocks to conserve energy. Otherwise the RS-FEC receive function operates normally. The value of rx_mode is passed to the client sublayer via the PMA:IS_RX_MODE.request primitive.

The rx_tx_mode parameter of the FEC:IS_RX_TX_MODE.indication primitive is used to communicate the link partner's value of tx_mode as inferred by the PMA. It is assigned the value that is received via the PMA:IS_RX_TX_MODE.indication primitive.

The energy_detect parameter of the FEC:IS_ENERGY_DETECT.indication primitive is used to communicate that the PMD has detected the return of energy on the interface following a period of quiescence. It is assigned the value that is received via the PMA:IS_ENERGY_DETECT.indication primitive.

91.3 PMA compatibility

The RS-FEC sublayer requires that the PMA service interface consist of exactly four upstream lanes and exactly four downstream lanes. Therefore, the RS-FEC sublayer may be a client of the PMA sublayer

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defined in Clause 83 when the PMA service interface width, *p*, is set to 4. The RS-FEC sublayer may also be a client of the PMA sublayer defined in Clause 94.

In addition, all PMA service interfaces between the RS-FEC sublayer and the PMD sublayer are required to consist of four or fewer upstream lanes and four or fewer downstream lanes. A consequence of this constraint is that a physical instantiation of the ten-lane PMA service interface (CAUI-10) may not be used below the RS-FEC sublayer.

91.4 Delay constraints

The maximum delay contributed by the RS-FEC sublayer (sum of transmit and receive delays at one end of the link) shall be no more than 40960 bit times (80 pause_quanta or 409.6 ns). A description of overall system delay constraints and the definitions for bit times and pause_quanta can be found in 80.4 and its references.

91.5 Functions within the RS-FEC sublayer

91.5.1 Functional block diagram

A functional block diagram of the RS-FEC sublayer is shown in Figure 91–2.

91.5.2 Transmit function

91.5.2.1 Lane block synchronization

The RS-FEC transmit function forms 20 bit streams by concatenating the bits from each of the 20 FEC:IS_UNITDATA_*i*.request primitives in the order they are received. It obtains lock to the 66-bit blocks in each bit stream using the sync headers and outputs 66-bit blocks. Block lock is obtained as specified in the block lock state diagram shown in Figure 82–12.

91.5.2.2 Alignment lock and deskew

Once the RS-FEC transmit function achieves block lock on a PCS lane, it then begins obtaining alignment marker lock as specified by the alignment marker lock state diagram shown in Figure 82–13. This process identifies the PCS lane number received on a particular lane of the service interface. After alignment marker lock is achieved on all 20 lanes, all inter-lane Skew is removed as specified by the PCS deskew state diagram shown in Figure 82–14. The RS-FEC transmit function shall support a maximum Skew of 49 ns between PCS lanes and a maximum Skew Variation of 400 ps. Skew and Skew Variation are defined in 80.5.

91.5.2.3 Lane reorder

PCS lanes can be received on different lanes of the service interface from which they were originally transmitted due to Skew between lanes and multiplexing by the PMA. The RS-FEC transmit function shall order the PCS lanes according to the PCS lane number.

91.5.2.4 Alignment marker removal

After all PCS lanes are aligned and deskewed, the PCS lanes are multiplexed together in the proper order to reconstruct the original stream of blocks and the alignment markers are removed from the data stream. Note that an alignment marker is always removed when am_lock is true for a given PCS lane even if it does not match the expected alignment marker value (due to a bit error for example). Repeated alignment marker

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errors result in am_lock being set to false for a given PCS lane, but until that happens it is sufficient to remove the block in the alignment marker position.

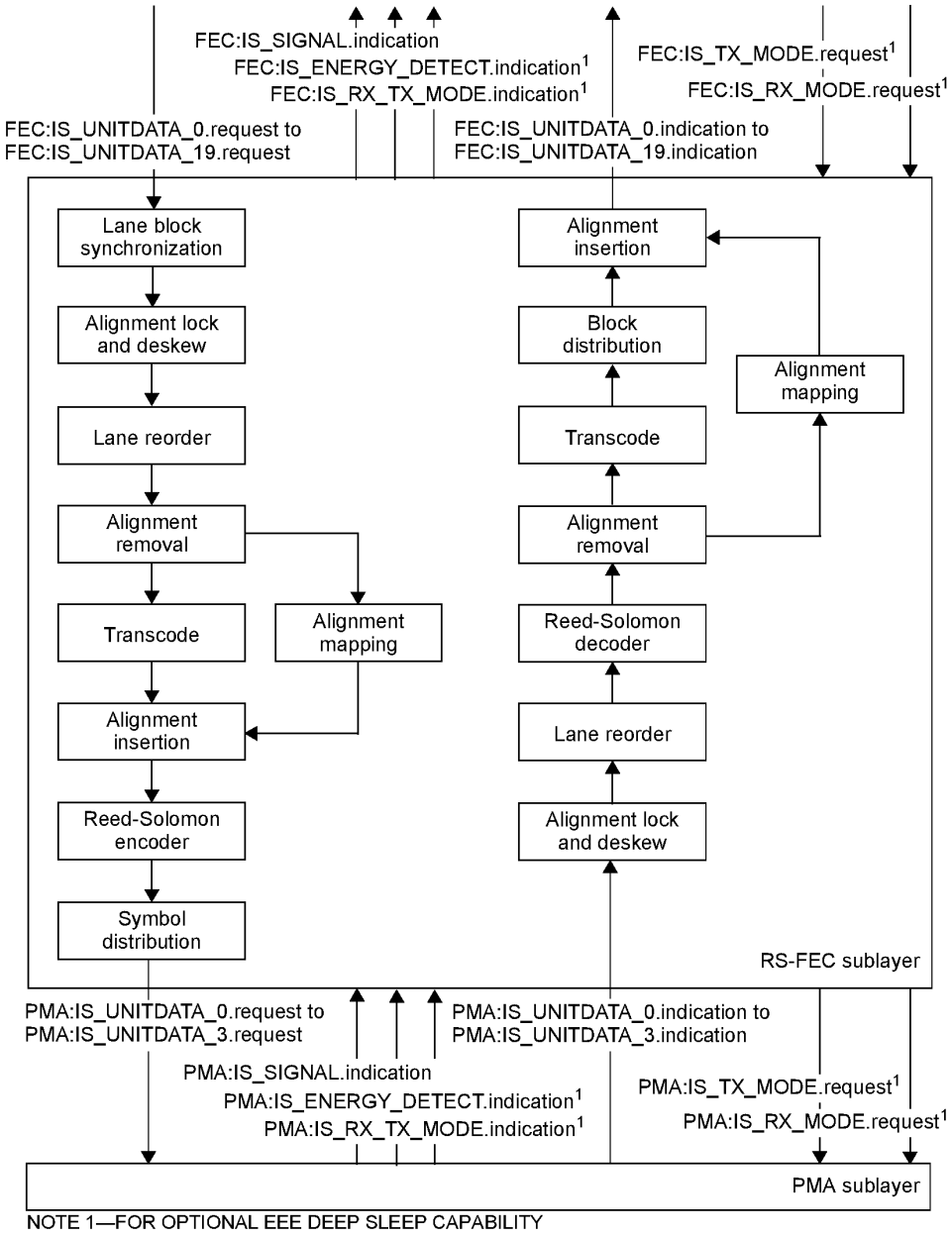


Figure 91–2—Functional block diagram

For the optional EEE deep sleep capability, transitions between normal alignment markers and Rapid Alignment Markers (RAMs) result in changes in relative position and frequency of alignment markers. These transitions are detected by the Transmit LPI state diagram (see Figure 91–10), and this information is used by the alignment marker removal function to determine which 66-bit blocks are to be removed.

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As part of the alignment marker removal process, the BIP_3 field is compared to the calculated Bit Interleaved Parity (BIP) value (see 82.2.8) for each PCS lane. If a Clause 45 MDIO is implemented, then the appropriate BIP error counter register (registers 1.230 to 1.249) is incremented by one each time the calculated BIP value does not equal the value received in the BIP_3 field. The incoming bit error ratio can be estimated by dividing the BIP block error ratio by a factor of 1081344.

91.5.2.5 64B/66B to 256B/257B transcoder

The transcoder constructs a 257-bit block, tx_scrambled<256:0>, from a group of four 66-bit blocks, tx_coded_*j*<65:0> where *j*=0 to 3. For each group of four 66-bit blocks, *j*=3 corresponds to the most recently received block. Bit 0 in each 66-bit block is the first bit received and corresponds to the first bit of the synchronization header.

If for all *j*=0 to 3, tx_coded_*j*<0>=0 and tx_coded_*j*<1>=1, tx_xcoded<256:0> shall be constructed as follows:

a) tx_xcoded<0> = 1
b) tx_xcoded<(64*j*+64):(64*j*+1)> = tx_coded_*j*<65:2> for *j*=0 to 3

If for all *j*=0 to 3, tx_coded_*j*<0> ≠ tx_coded_*j*<1> (valid synchronization header) and for any *j*=0 to 3, tx_coded_*j*<0>=1 and tx_coded_*j*<1>=0, tx_xcoded<256:0> shall be constructed as follows:

a1) tx_xcoded<0> = 0
b1) tx_xcoded<*j*+1> = tx_coded_*j*<1> for *j*=0 to 3
c1) Let *c* be the smallest value of *j* such that tx_coded_*c*<0>=1. In other words, tx_coded_*c* is the first 66-bit control block that was received in the current group of four blocks.
d1) Let tx_payloads<(64*j*+63):64*j*> = tx_coded_*j*<65:2> for *j*=0 to 3
e1) Omit tx_coded_*c*<9:6>, which is the second nibble (based on transmission order) of the block type field for tx_coded_*c*, from tx_xcoded per the following expressions.
tx_xcoded<(64*c*+8):5> = tx_payloads<(64*c*+3):0>
tx_xcoded<256:(64*c*+9)> = tx_payloads<255:(64*c*+8)>

If for any *j*=0 to 3, tx_coded_*j*<0> = tx_coded_*j*<1> (invalid synchronization header), tx_xcoded<256:0> shall be constructed as follows:

a2) tx_xcoded<0> = 0
b2) tx_xcoded<*j*+1> = 1 for *j*=0 to 3
c2) Let tx_payloads<(64*j*+63):64*j*> = tx_coded_*j*<65:2> for *j*=0 to 3
d2) Omit the second nibble (based on transmission order) of tx_coded_0 per the following expressions.
tx_xcoded<8:5> = tx_payloads<3:0>
tx_xcoded<256:9> = tx_payloads<255:8>

Several examples of the construction of tx_xcoded<256:0> are shown in Figure 91–3. In Figure 91–3, d_*j* indicates the *j*th 66-bit block contains only data octets, c_*j* indicates the *j*th 66-bit block contains one or more control characters, f_*j* denotes the first nibble of the block type field for 66-bit block *j*, and s_*j* denotes the second nibble of the block type field for 66-bit block *j*.

Finally, scramble the first 5 bits, based on transmission order, of tx_xcoded<256:0> to yield tx_scrambled<256:0> as follows:

a3) Set tx_scrambled<4:0> to the result of the bit-wise exclusive-OR of the tx_xcoded<4:0> and tx_xcoded<12:8>.
b3) Set tx_scrambled<256:5> to tx_xcoded<256:5>

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For each 257-bit block, bit 0 shall be the first bit transmitted.

91.5.2.6 Alignment marker mapping and insertion

The alignment markers that were removed per 91.5.2.4 are re-inserted after being processed by the alignment marker mapping function. The alignment marker mapping function compensates for the operation of the symbol distribution function defined in 91.5.2.8 and rearranges the alignment marker bits so that they appear on the FEC lanes intact and in the desired sequence. This preserves the properties of the alignment markers (e.g., DC balance, transition density) and provides a deterministic pattern for the purpose of synchronization. The RS-FEC receive function uses knowledge of this mapping to determine the FEC lane that is received on a given lane of the PMA service interface, to compensate for skew between FEC lanes, and to identify RS-FEC codeword boundaries.

The alignment marker mapping function operates on a group of 20 aligned and reordered alignment markers. Let am_tx_*x*<65:0> be the alignment marker for PCS lane *x*, *x*=0 to 19, where bit 0 is the first bit transmitted. The alignment markers shall be mapped to am_txmapped<1284:0> in a manner that yields the same result as the following process.

For *x*=0 to 19, amp_tx_*x*<63:0> is constructed as follows:

a) Set *y* = 0 when $x \leq 3$, set *y* = 16 when $x \geq 16$, otherwise set *y* = *x*.
b) amp_tx_*x*<23:0> is set to M_0, M_1, and M_2 as shown in Figure 82–9 (bits 25 to 2) using the values in Table 82–2 for PCS lane number *y*. If am_tx_*x* corresponds to a Rapid Alignment marker, then the M_4, M_5, and M_6 values are used instead (see Figure 82–11).
c) amp_tx_*x*<31:24> = am_tx_*x*<33:26>
d) amp_tx_*x*<55:32> is set to M_4, M_5, and M_6 as shown in Figure 82–9 (bits 57 to 34) using the values in Table 82–2 for PCS lane number *y*. If am_tx_*x* corresponds to a Rapid Alignment marker, then the M_0, M_1, and M_2 values are used instead (see Figure 82–11).
e) amp_tx_*x*<63:56> = am_tx_*x*<65:58>

This process replaces the fixed bytes of the alignment markers received, possibly with errors, with the values from Table 82–2. In addition it substitutes the fixed bytes of the alignment markers corresponding to PCS lanes 1, 2, and 3 with the fixed bytes for the alignment marker corresponding to PCS lane 0. Similarly, it substitutes the fixed bytes of the alignment markers corresponding to PCS lanes 17, 18, and 19 with the fixed bytes for the alignment marker corresponding to PCS lane 16. The variable bytes BIP or CD are unchanged. This process simplifies receiver synchronization since the receiver only needs to search for the fixed bytes corresponding to PCS lane 0 on each FEC lane. When the optional EEE deep sleep capability is supported, the receiver only needs to search for the fixed bytes corresponding to PCS lanes 0 and 16.

Construct a matrix of 4 rows and 320 columns, am_txpayloads, as shown in Figure 91–4. Given *i*=0 to 3, *j*=0 to 4, and *x*=*i*+4*j*, the matrix is derived per the following expression:

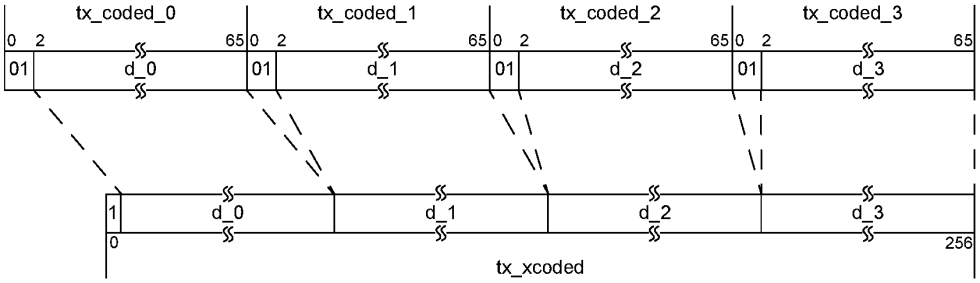
am_txpayloads<*i*, (64*j*+63):64*j*> = amp_tx_*x*<63:0>

Given *i*=0 to 3, *k*=0 to 31, and *y*=*i*+4*k*, am_txmapped may then be derived from am_txpayloads per the following expression:

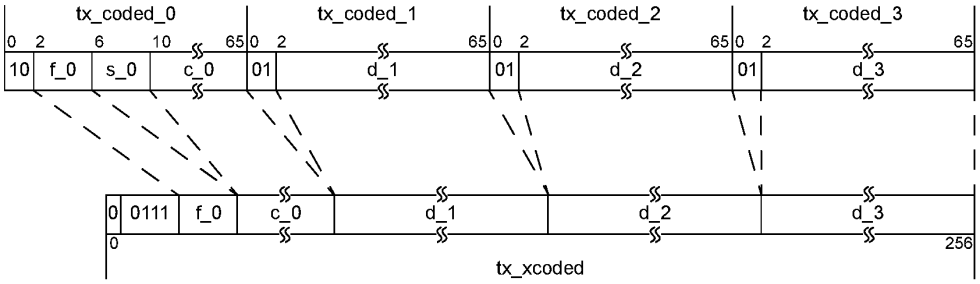
am_txmapped<(10*y*+9):10*y*> = am_txpayloads<*i*, (10*k*+9):10*k*>

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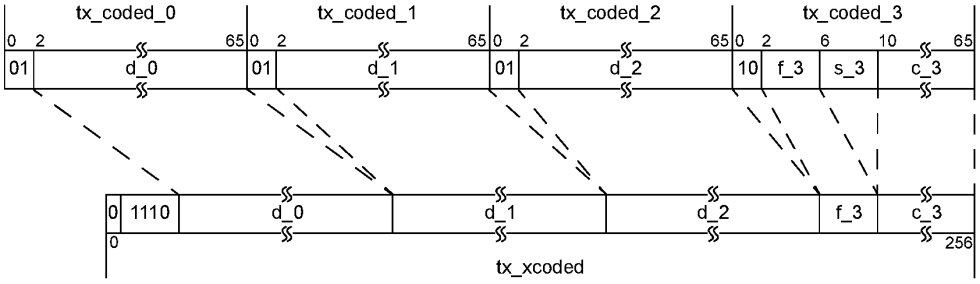
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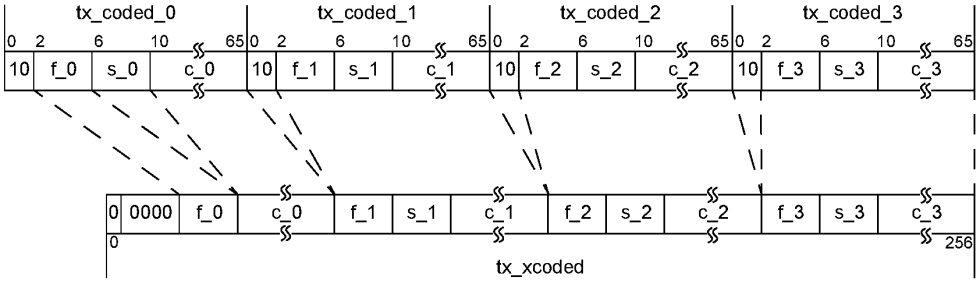
Example 1: All data blocks



Example 2: Control block followed by three data blocks



Example 3: Three data blocks followed by a control block



Example 4: All control blocks

Figure 91–3—Examples of the construction of tx_xcoded

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A 5-bit pad is appended to the mapped alignment markers to yield the equivalent of five 257-bit blocks. The pad bits, am_txmapped<1284:1280>, shall be set to the binary values 00101 and 11010 (the leftmost bit is assigned to the highest bit index) in an alternating pattern. In other words, if a pad value of 00101 is used for the current iteration of the mapping function, a value of 11010 is used in the next iteration and vice versa.

The result of the alignment marker mapping function is a deterministic mapping between alignment marker payloads and FEC lanes. The alignment marker payloads corresponding to PCS lanes 0, 4, 8, 12, and 16 are transmitted on FEC lane 0, the alignment marker payloads corresponding to PCS lanes 0, 5, 9, 13, and 16 are transmitted on FEC lane 1, and so on (see Figure 91–4).

As a result of this process, the BIP_3 and BIP_7 fields from normal alignment markers are carried across the link protected by FEC. These fields cannot be used to monitor errors on the link protected by FEC as 64B/66B to 256B/257B transcoding and Reed-Solomon encoding alters the bit sequence. However, these fields may again be used to monitor errors after the original bit sequence is restored, i.e., following Reed-Solomon decoding and 256B/257B to 64B/66B transcoding.

One group of aligned and reordered alignment markers are mapped every 20 × 16384 66-bit blocks. This corresponds to 4096 Reed-Solomon codewords (refer to 91.5.2.7). The mapped alignment markers, am_txmapped<1284:0> shall be inserted as the first 1285 message bits to be transmitted from every 4096th codeword.

For the optional EEE deep sleep capability, when tx_lpi_active is true, one group of Rapid Alignment Markers (see 82.2.9) are mapped every 20 × 8 66-bit blocks. This corresponds to 2 Reed-Solomon codewords. The mapped Rapid Alignment Markers, am_txmapped<1284:0> shall be inserted as the first 1285 message bits to be transmitted from every other codeword.

The first 257-bit block inserted after am_txmapped shall correspond to the four 66-bit blocks received on PCS lanes 0, 1, 2, and 3 that immediately followed the alignment marker on each respective lane.

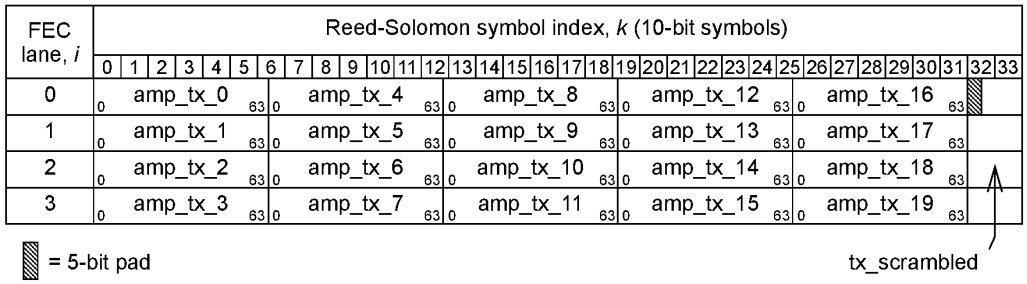


Figure 91–4—Alignment marker mapping to FEC lanes

91.5.2.7 Reed-Solomon encoder

The RS-FEC sublayer employs a Reed-Solomon code operating over the Galois Field GF(2^{10}) where the symbol size is 10 bits. The encoder processes k message symbols to generate $2t$ parity symbols, which are then appended to the message to produce a codeword of $n=k+2t$ symbols. For the purposes of this clause, a particular Reed-Solomon code is denoted RS(n,k).

When used to form a 100GBASE-CR4, 100GBASE-KR4, or 100GBASE-SR4 PHY, the RS-FEC sublayer shall implement RS(528,514). When used to form a 100GBASE-KP4 PHY, the RS-FEC sublayer shall implement RS(544,514). Each k-symbol message corresponds to 20 257-bit blocks produced by the transcoder. Each code is based on the generating polynomial given by Equation (91–1).

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$$g(x) = \prod_{j=0}^{2t-1}(x-\alpha^j) = g_{2t}x^{2t} + g_{2t-1}x^{2t-1} + \ldots + g_1 x + g_0 \quad (91\text{–}1)$$

In Equation (91–1), α is a primitive element of the finite field defined by the polynomial $x^{10}+x^3+1$.

Equation (91–2) defines the message polynomial $m(x)$ whose coefficients are the message symbols m_{k-1} to m_0.

$$m(x) = m_{k-1}x^{n-1} + m_{k-2}x^{n-2} + \ldots + m_1 x^{2t+1} + m_0 x^{2t} \quad (91\text{–}2)$$

Each message symbol m_i is the bit vector $(m_{i,9}, m_{i,8}, \ldots, m_{i,1}, m_{i,0})$, which is identified with the element $m_{i,9}\alpha^9 + m_{i,8}\alpha^8 + \ldots + m_{i,1}\alpha + m_{i,0}$ of the finite field. The message symbols are composed of the bits of the transcoded blocks tx_scrambled (including a mapped group of alignment markers when appropriate) such that bit 0 of the first transcoded block in the message (or am_txmapped<0>) is bit 0 of m_{k-1} and bit 256 of the last transcoded block in the message is bit 9 of m_0. The first symbol input to the encoder is m_{k-1}.

Equation (91–3) defines the parity polynomial $p(x)$ whose coefficients are the parity symbols p_{2t-1} to p_0.

$$p(x) = p_{2t-1}x^{2t-1} + p_{2t-2}x^{2t-2} + \ldots + p_1 x + p_0 \quad (91\text{–}3)$$

The parity polynomial is the remainder from the division of $m(x)$ by $g(x)$. This may be computed using the shift register implementation illustrated in Figure 91–5. The outputs of the delay elements are initialized to zero prior to the computation of the parity for a given message. After the last message symbol, m_0, is processed by the encoder, the outputs of the delay elements are the parity symbols for that message.

The codeword polynomial $c(x)$ is then the sum of $m(x)$ and $p(x)$ where the coefficient of the highest power of x, $c_{n-1} = m_{k-1}$ is transmitted first and the coefficient of the lowest power of x, $c_0 = p_0$ is transmitted last. The first bit transmitted from each symbol is bit 0.

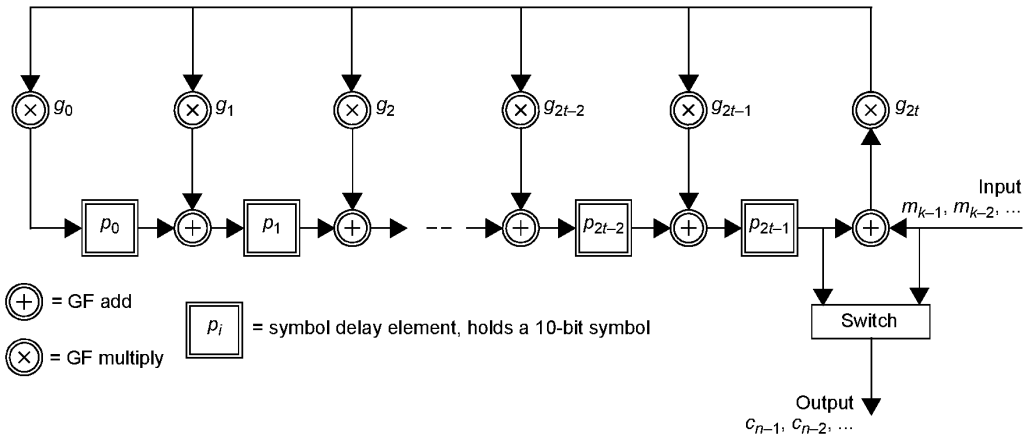


Figure 91–5—Reed-Solomon encoder functional model

The coefficients of the generator polynomial for each code are presented in Table 91–1. Example codewords for each code are provided in Annex 91A.

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Table 91–1—Coefficients of the generator polynomial g_i (decimal)

i	RS(528,514)	RS(544,514)	*i*	RS(528,514)	RS(544,514)	*i*	RS(528,514)	RS(544,514)
0	432	523	11	701	883	22		565
1	290	834	12	6	503	23		108
2	945	128	13	904	942	24		1
3	265	158	14	1	385	25		552
4	592	185	15		495	26		230
5	391	127	16		720	27		187
6	614	392	17		94	28		552
7	900	193	18		132	29		575
8	925	610	19		593	30		1
9	656	788	20		249			
10	32	361	21		282			

91.5.2.8 Symbol distribution

Once the data has been Reed-Solomon encoded, it shall be distributed to 4 FEC lanes, one 10-bit symbol at a time in a round robin distribution from the lowest to the highest numbered FEC lane. The distribution process is shown in Figure 91–6.

When used to form a 100GBASE-KP4 PHY, the PMA:IS_UNITDATA_*i*.request primitive is defined to include an additional parameter (refer to 94.2.1.1.1). At the beginning of an FEC codeword, the parameter start=TRUE is asserted for the first bit of the first four symbols of the codeword transferred across the four primitives. Otherwise the parameter start is set to FALSE.

91.5.2.9 Transmit bit ordering

The transmit bit ordering is illustrated in Figure 91–6.

91.5.3 Receive function

91.5.3.1 Alignment lock and deskew

The RS-FEC receive function forms 4 bit streams by concatenating the bits from each of the 4 PMA:IS_UNITDATA_*i*.indication primitives in the order they are received. It obtains lock to the alignment markers as specified by the FEC synchronization state diagram shown in Figure 91–8.

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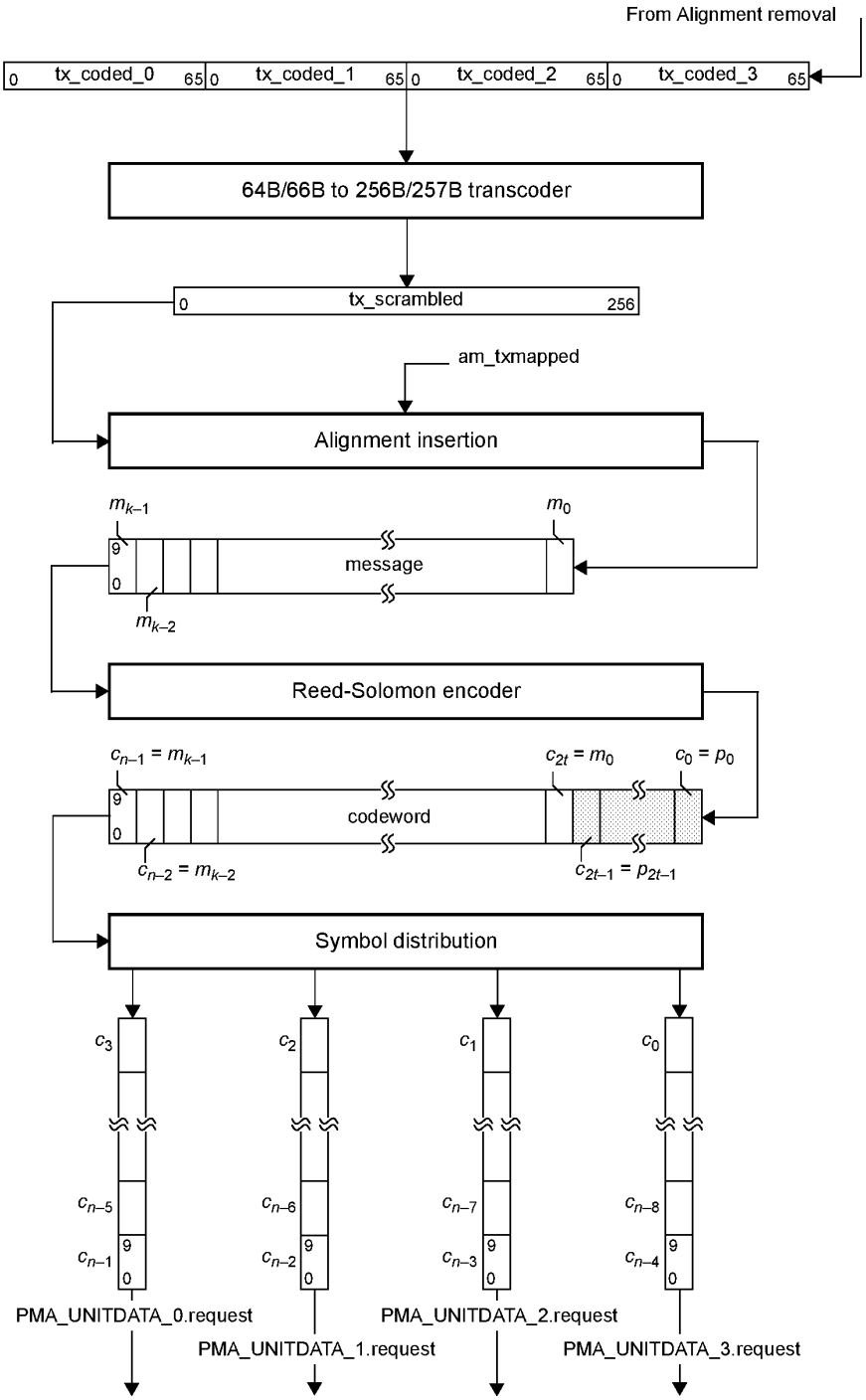


Figure 91–6—Transmit bit ordering

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After alignment marker lock is achieved on all 4 lanes, all inter-lane Skew is removed as specified by the FEC alignment state diagram shown in Figure 91–9. The FEC receive function shall support a maximum Skew of 180 ns between FEC lanes and a maximum Skew Variation of 4 ns.

The 100GBASE-KP4 PMA transmit function (refer to 94.2.2) inserts PMA-specific overhead that is aligned with the start of a Reed-Solomon codeword. The 100GBASE-KP4 PMA receive function (refer to 94.2.3) synchronizes to this overhead and indicates the first bit of each of the first four symbols in a codeword by setting the PMA:IS_UNITDATA_*i*.indication parameter start=TRUE (see 94.2.1.2).

91.5.3.2 Lane reorder

FEC lanes can be received on different lanes of the service interface from which they were originally transmitted. The FEC receive function shall order the FEC lanes according to the FEC lane number (see 91.5.2.6). The FEC lane number is defined by the sequence of alignment markers that are mapped to each FEC lane.

After all FEC lanes are aligned, deskewed, and reordered, the FEC lanes are multiplexed together in the proper order to reconstruct the original stream of FEC codewords.

91.5.3.3 Reed-Solomon decoder

The Reed-Solomon decoder extracts the message symbols from the codeword, corrects them as necessary, and discards the parity symbols. The message symbols correspond to 20 transcoded blocks rx_scrambled.

When used to form a 100GBASE-CR4, 100GBASE-KR4, or 100GBASE-SR4 PHY, the RS-FEC sublayer shall be capable of correcting any combination of up to t=7 symbol errors in a codeword. When used to form a 100GBASE-KP4 PHY, the RS-FEC sublayer shall be capable of correcting any combination of up to t=15 symbol errors in a codeword. The RS-FEC sublayer shall also be capable of indicating when an errored codeword was not corrected. The probability that the decoder fails to indicate a codeword with t+1 errors as uncorrected is not expected to exceed 10^{-6}. This limit is also expected to apply for t+2 errors, t+3 errors, and so on.

The Reed-Solomon decoder may provide the option to perform error detection without error correction to reduce the delay contributed by the RS-FEC sublayer. The presence of this option is indicated by the assertion of the FEC_bypass_correction_ability variable (see 91.6.3). When the option is provided, it is enabled by the assertion of the FEC_bypass_correction_enable variable (see 91.6.1). This option shall not be used when the RS-FEC sublayer is used to form part of a 100GBASE-SR4 PHY.

NOTE—The PHY may rely on the error correction capability of the RS-FEC sublayer to achieve its performance objectives. It is recommended that acceptable performance of the underlying link is verified before error correction is bypassed.

The Reed-Solomon decoder indicates errors to the PCS sublayer by intentionally corrupting 66-bit block synchronization headers. When the decoder determines that a codeword contains errors (when the bypass correction feature is enabled) or contains errors that were not corrected (when the bypass correction feature is not supported or not enabled), it shall ensure that, for every other 257-bit block within the codeword starting with the first (1st, 3rd, 5th, etc.), the synchronization header for the first 66-bit block at the output of the 256B/257B to 64B/66B transcoder, rx_coded_0<1:0>, is set to 11. In addition, it shall ensure rx_coded_0<1:0> corresponding to the 6th 257-bit block and rx_coded_3<1:0> corresponding to the last (20th) 257-bit block in the codeword are set to 11. This causes the PCS to discard all frames 64 bytes and larger that are fully or partially within the codeword.

The Reed-Solomon decoder may optionally provide the ability to bypass the error indication feature to reduce the delay contributed by the RS-FEC sublayer. The presence of this option is indicated by the asser-

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tion of the FEC_bypass_indication_ability variable (see 91.6.4). When the option is provided it is enabled by the assertion of the FEC_bypass_indication_enable variable (see 91.6.2).

When FEC_bypass_correction_enable is asserted, the decoder shall not bypass error indication and the value of FEC_bypass_indication_enable has no effect.

When FEC_bypass_indication_enable is asserted, additional error monitoring is performed by the RS-FEC sublayer to reduce the likelihood that errors in a packet are not detected. The Reed-Solomon decoder counts the number of symbol errors detected on all four FEC lanes in consecutive non-overlapping blocks of 8192 codewords. When the number of symbol errors in a block of 8192 codewords exceeds K, the Reed-Solomon decoder shall cause synchronization header rx_coded<1:0> of each subsequent 66-bit block that is delivered to the PCS to be assigned a value of 00 or 11 for a period of 60 ms to 75 ms. As a result, the PCS sets hi_ber=true, which inhibits the processing of received packets. When Auto-Negotiation is supported and enabled, assertion of hi_ber causes Auto-Negotiation to restart.

For the optional EEE deep sleep capability, the error monitor employed when FEC_bypass_indication_enable is asserted shall be disabled when rx_lpi_active=true. The next block of 8192 codewords considered by the error monitor shall begin on the codeword boundary following the transition of rx_lpi_active from true to false.

When the RS-FEC sublayer is used to form a 100GBASE-CR4, 100GBASE-KR4, or 100GBASE-SR4 PHY, the symbol error threshold shall be K=417. When the RS-FEC sublayer used to form a 100GBASE-KP4 PHY, the symbol error threshold shall be K=6380.

91.5.3.4 Alignment marker removal

The first 1285 message bits in every 4096th codeword is the vector am_rxmapped<1284:0> where bit 0 is the first bit received. The specific codewords that include this vector are indicated by the alignment lock and deskew function (refer to 91.5.3.1).

For the optional EEE deep sleep capability, transitions between normal alignment markers and Rapid Alignment Markers result in changes in the relative position and frequency of am_rxmapped<1284:0>. These transitions are detected by the Receive LPI state diagram (see Figure 91–11) and this information is used by the alignment marker removal function to determine which bits are to be removed. When rx_lpi_active is true, the first 1285 message bits in every other codeword is the vector am_rxmapped<1284:0>.

The vector am_rxmapped shall be removed prior to transcoding.

91.5.3.5 256B/257B to 64B/66B transcoder

The transcoder extracts a group of four 66-bit blocks, rx_coded_j<65:0> where j=0 to 3, from each 257-bit block rx_scrambled<256:0>. Bit 0 of the 257-bit block is the first bit received.

First, descramble the first 5 bits, based on reception order, of rx_scrambled<256:0> to yield rx_xcoded<256:0> as follows.

a) Set rx_xcoded<4:0> to the result of the bit-wise exclusive-OR of the rx_scrambled<4:0> and rx_scrambled<12:8>.
b) Set rx_xcoded<256:5> to rx_scrambled<256:5>.

If rx_xcoded<0> is 1, rx_coded_j<65:0> for j=0 to 3 shall be derived as follows.

a1) rx_coded_j<65:2> = rx_xcoded<(64j+64):(64j+1)> for j=0 to 3
b1) rx_coded_j<0>=0 and rx_coded_j<1>=1 for all j=0 to 3

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If rx_xcoded<0> is 0 and any rx_xcoded<*j*+1>=0 for *j*=0 to 3, rx_coded_*j*<65:0> for *j*=0 to 3 shall be derived as follows.

a2) Let *c* be the smallest value of *j* such that rx_xcoded<*j*+1>=0. In other words, rx_coded_*c* is the first 66-bit control block in the resulting group of four blocks.
b2) Let rx_payloads be a vector representing the payloads of the four 66-bit blocks. It is derived using the following expressions:
rx_payloads<(64*c*+3):0> = rx_xcoded<(64*c*+8):5>
rx_payloads<(64*c*+7):(64*c*+4)> = 0000 (an arbitrary value that is later replaced by s_*c*)
rx_payloads<255:(64*c*+8)> = rx_xcoded<256:(64*c*+9)>
c2) rx_coded_*j*<65:2> = rx_payloads<(64*j*+63):64*j*> for *j*=0 to 3
d2) Let f_*c*<3:0> = rx_coded_*c*<5:2> be the scrambled first nibble (based on transmission order) of the block type field for rx_coded_*c*.
e2) Descramble f_*c*<3:0> to yield g<3:0> per the following expression where "^" denotes the exclusive-OR operation. When *c*=0, rx_coded_(*c*–1) corresponds to rx_coded_3 from the previous 257-bit block.
g<*i*> = f_*c*<*i*> ^ rx_coded_(*c*–1)<*i*+8> ^ rx_coded_(*c*–1)<*i*+27> for *i*=0 to 3
f2) The block type field may be uniquely identified by either its most or least significant nibble. Since g<3:0> is the least significant nibble of the block type field (per the transmission order), derive h<3:0> by cross-referencing to g<3:0> using Figure 82–5. For example, if g<3:0> is 0xE then h<3:0> is 0x1. If no match to g<3:0> is found, h<3:0> is set to 0000.
g2) If rx_xcoded<*j*+1>=0, rx_coded_*j*<0>=1 and rx_coded_*j*<1>=0 for *j*=0 to 3
h2) If rx_xcoded<*j*+1>=1, rx_coded_*j*<0>=0 and rx_coded_*j*<1>=1 for *j*=0 to 3
i2) If h<3:0> = 0000, rx_coded_*c*<1>=1 (invalidate synchronization header)

If rx_xcoded<0> is 0 and all rx_xcoded<*j*+1>=1 for *j*=0 to 3, rx_coded_*j*<65:0> for *j*=0 to 3 shall be derived as follows.

a3) Set *c* = 0 and h<3:0> = 0000.
b3) Let rx_payloads be a vector representing the payloads of the four 66-bit blocks. It is derived using the following expressions.
rx_payloads<(64*c*+3):0> = rx_xcoded<(64*c*+8):5>
rx_payloads<(64*c*+7):(64*c*+4)> = 0000 (an arbitrary value that is later replaced by s_*c*)
rx_payloads<255:(64*c*+8)> = rx_xcoded<256:(64*c*+9)>
c3) rx_coded_*j*<65:2> = rx_payloads<(64*j*+63):(64*j*)> for *j*=0 to 3
d3) rx_coded_*j*<0>=0 and rx_coded_*j*<1>=0 for *j*=0 and 2
e3) rx_coded_*j*<0>=1 and rx_coded_*j*<1>=1 for *j*=1 and 3

If rx_xcoded<0> is 0, scramble h<3:0> to yield s_*c*<3:0> and assign it to rx_coded_*c* per the following expressions.

a4) s_*c*<*i*> = h<*i*> ^ rx_coded_(*c*–1)<*i*+12> ^ rx_coded_(*c*–1)<*i*+31> for *i*=0 to 3
b4) rx_coded_*c*<9:6> = s_*c*<3:0>

The 66-bit blocks are transmitted in order from *j*=0 to 3. Bit 0 of each block is the first bit transmitted.

91.5.3.6 Block distribution

After the data has been transcoded, it shall be distributed to multiple PCS lanes, one 66-bit block at a time in a round robin distribution from the lowest to the highest numbered PCS lanes. The distribution process is shown in Figure 82–6.

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91.5.3.7 Alignment marker mapping and insertion

The alignment marker mapping function compensates for operation of lane reorder function (refer to 91.5.3.2) to derive the PCS lane alignment markers, am_rx_*x*<65:0> for *x*=0 to 19, from am_rx-mapped<1284:0> (refer to 91.5.3.4).

The alignment markers shall be derived from am_rxmapped<1284:0> in a manner that yields the same result as the following process.

Given *i*=0 to 3, *k*=0 to 31, and *y*=*i*+4*k*, am_rxpayloads may be derived from am_rxmapped per the following expression:

am_rxpayloads<*i*, (10*k*+9):10*k*> = am_rxmapped<(10*y*+9):10*y*>

The 5-bit pad am_rxmapped<1284:1280> is ignored. Given *i*=0 to 3, *j*=0 to 4, and *x*=*i*+4*j*, amp_rx_*x* may be derived from am_rxpayloads by the following expression:

amp_rx_*x*<63:0> = am_rxpayloads<*i*, (64*j*+63):64*j*>

For *x*=0 to 19, am_rx_*x*<65:0> is constructed as follows:

a) am_rx_*x*<0>=1 and am_rx_*x*<1>=0.
b) am_rx_*x*<25:2> is set to M_0, M_1, and M_2 as shown in Figure 82–9 using the values in Table 82–2 for PCS lane number *x*. If amp_rx_*x* corresponds to a Rapid Alignment marker, then the M_4, M_5, and M_6 values are used instead (see Figure 82–11).
c) am_rx_*x*<33:26> = amp_rx_*x*<31:24>.
d) am_rx_*x*<57:34> is set to M_4, M_5, and M_6 as shown in Figure 82–9 using the values in Table 82–2 for PCS lane number *x*. If amp_rx_*x* corresponds to a Rapid Alignment marker, then the M_0, M_1, and M_2 values are used instead (see Figure 82–11).
e) am_rx_*x*<65:58> = amp_rx_*x*<63:56>.

One vector is mapped to 20 alignment markers every 4096 Reed-Solomon codewords (see 91.5.3.4). The alignment markers are simultaneously transmitted on the 20 PCS lanes after every 16383rd column of 20 66-bit blocks.

For the optional EEE deep sleep capability, when rx_lpi_active is true, one vector is mapped to 20 Rapid Alignment Markers every 2 Reed-Solomon codewords. The Rapid Alignment Markers are simultaneously transmitted on the 20 PCS lanes after every 7th column of 20 66-bit blocks.

The alignment markers am_rx_0 to am_rx_3 shall be inserted so that they are immediately followed by rx_coded_0 to rx_coded_3, respectively, as derived from the first 257-bit block following am_rxmapped. Similarly am_rx_4 to am_rx_7 are followed by the 66-bit blocks corresponding to the second 257-bit block following am_rxmapped, and so on.

91.5.3.8 Receive bit ordering

The receive bit ordering is illustrated in Figure 91–7. This illustration shows the case where the FEC lanes appear across the PMA:IS_UNITDATA_*i*.indication primitives in the correct order.

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91.5.4 Detailed functions and state diagrams

91.5.4.1 State diagram conventions

The body of this subclause is comprised of state diagrams, including the associated definitions of variables, functions, and counters. Should there be a discrepancy between a state diagram and descriptive text, the state diagram prevails.

The notation used in the state diagrams follows the conventions of 21.5. The notation ++ after a counter or integer variable indicates that its value is to be incremented.

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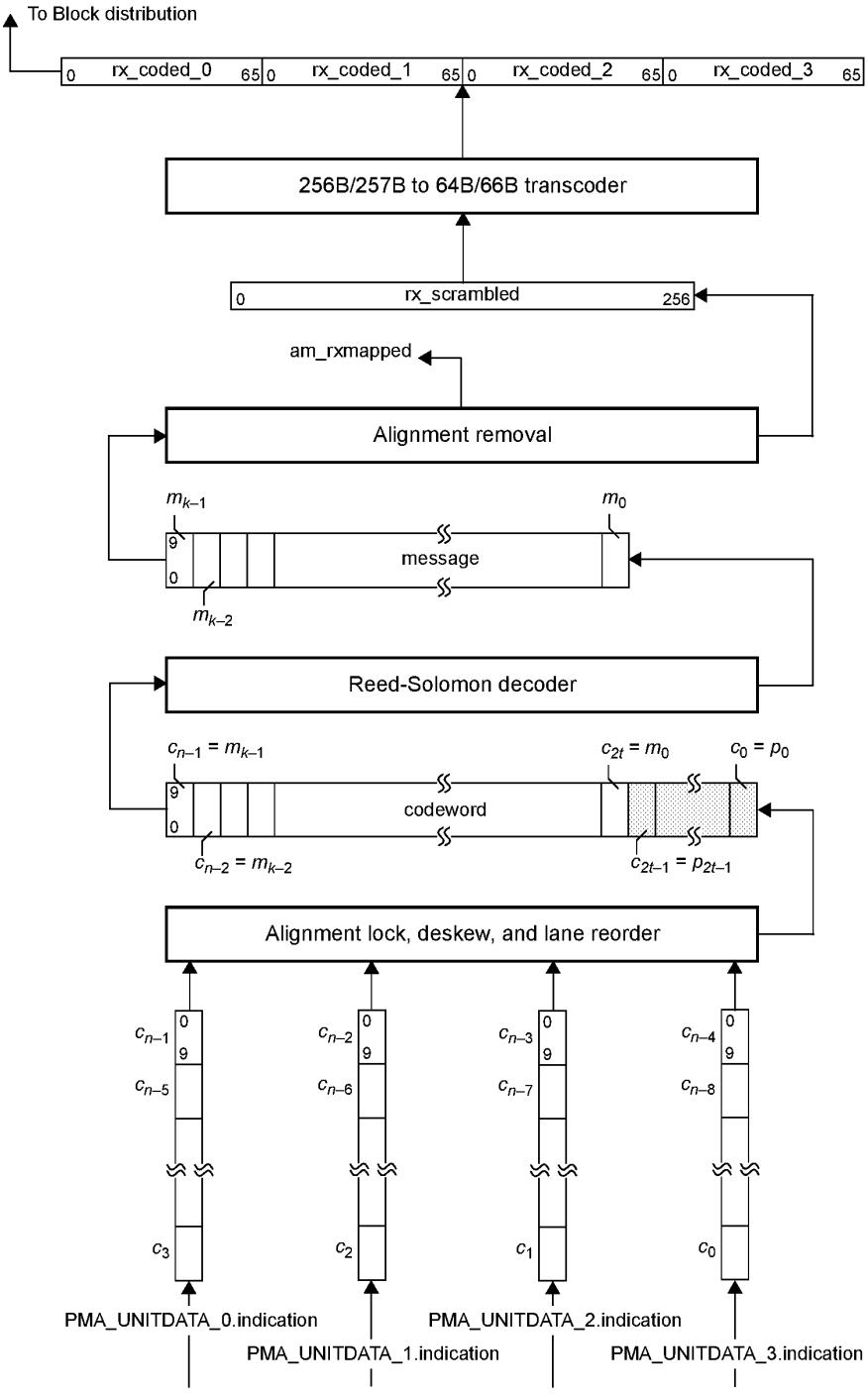


Figure 91–7—Receive bit ordering

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91.5.4.2 State variables

91.5.4.2.1 Variables

all_locked
: A Boolean variable that is set to true when amps_lock<*x*> is true for all *x* and is set to false when amps_lock<*x*> is false for any *x*.

amp_counter_done
: Boolean variable that indicates that amp_counter has reached its terminal count.

amp_match
: Boolean variable that holds the output of the function AMP_COMPARE.

amp_valid
: Boolean variable that is set to true if the received 64-bit block is a valid alignment marker payload. The alignment marker payload, mapped to an FEC lane according to the process described in 91.5.2.6, consists of 48 known bits and 16 variable bits (the BIP_3 or CD_3 field and its complement BIP_7 or CD_7, see 82.2.7). The bits of the candidate block that are in the positions of the known bits in the alignment marker payload are compared on a nibble-wise basis (12 comparisons). If no more than 3 nibbles in the candidate block fail to match the corresponding known nibbles in the alignment marker payload, the candidate block is considered a valid alignment marker payload. For the normal mode of operation, each FEC lane compares the candidate block to the alignment marker payload for PCS lane 0. For the optional EEE deep sleep capability, each FEC lane also compares the candidate block to the alignment marker payload for PCS lane 16 when rx_lpi_active is true.

amps_lock<*x*>
: Boolean variable that is set to true when the receiver has detected the location of the alignment marker payload sequence for a given lane on the PMA service interface, where *x* = 0:3.

current_pcsl
: A variable that holds the PCS lane number corresponding to the current alignment marker payload that is recognized on a given lane of the PMA service interface. It is compared to the variable first_pcsl to confirm that the location of the alignment marker payload sequence has been detected.

cw_bad
: A Boolean variable that is set to true if the Reed-Solomon decoder (see 91.5.3.3) fails to correct the current FEC codeword and is set to false otherwise.

deskew_done
: A Boolean variable that is set to true when fec_enable_deskew is set to true and the deskew process is completed. Otherwise, this variable is set to false.

fec_align_status
: A variable set by the FEC alignment process to reflect the status of FEC lane-to-lane alignment. Set to true when all lanes are synchronized and aligned and set to false when the deskew process is not complete.

fec_alignment_valid
: Boolean variable that is set to true if all FEC lanes are aligned. FEC lanes are considered to be aligned when amps_lock<*x*> is true for all *x*, each FEC lane is locked to a unique alignment marker payload sequence (see 91.5.2.6), and the FEC lanes are deskewed. Otherwise, this variable is set to false.

fec_enable_deskew
: A Boolean variable that enables and disables the deskew process. Received bits may be discarded whenever deskew is enabled. It is set to true when deskew is enabled and set to false when deskew is disabled.

fec_lane
: A variable that holds the FEC lane number (0 to 3) received on lane *x* of the PMA service interface when amps_lock<*x*>=true. The FEC lane number is determined by the alignment marker payloads in the 2nd, 3rd, or 4th positions of the sequence based on the mapping defined in 91.5.2.6. The 48 bits that are in the positions of the known bits in the received alignment marker payload are

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compared to the expected values for a given payload position and FEC lane on a nibble-wise basis (12 comparisons). If no more than 3 nibbles in the candidate block fail to match the corresponding known nibbles for any payload position on a given FEC lane, then the FEC lane number is assigned accordingly.

first_pcsl
: A variable that holds the PCS lane number that corresponds to the first alignment marker payload that is recognized on a given lane of the PMA service interface. It is compared to the PCS lane number corresponding to the second alignment marker payload that is tested.

reset
: Boolean variable that controls the resetting of the RS-FEC sublayer. It is true whenever a reset is necessary including when reset is initiated from the MDIO, during power on, and when the MDIO has put the RS-FEC sublayer into low-power mode.

restart_lock
: Boolean variable that is set by the FEC alignment process to reset the synchronization process on all FEC lanes. It is set to true after 3 consecutive uncorrected codewords are received (3_BAD state) and set to false upon entry into the LOSS_OF_ALIGNMENT state.

rx_align_status
: Boolean variable that is set by the alignment lock and deskew function (see 91.5.2.2).

signal_ok
: Boolean variable that is set based on the most recently received value of PMA:IS_SIGNAL.indication(SIGNAL_OK). It is true if the value was OK and false if the value was FAIL.

slip_done
: Boolean variable that is set to true when the SLIP requested by the synchronization state diagram has been completed indicating that the next candidate 64-bit block position can be tested.

test_amp
: Boolean variable that is set to true when a candidate block position is available for testing and false when the FIND_1ST state is entered.

test_cw
: Boolean variable that is set to true when a new FEC codeword is available for decoding and is set to false when the TEST_CW state is entered.

The following variables are only used for the optional EEE deep sleep capability. If this capability is not supported, the values of tx_lpi_active and rx_lpi_active are set to false.

1st_ram_counter_done
: Boolean variable that indicates that 1st_ram_counter has reached its terminal count.

1st_ramps_counter_done
: Boolean variable that indicates that 1st_ramps_counter has reached its terminal count.

fec_lpi_fw
: Boolean variable that controls the behavior of the Transmit LPI and Receive LPI state diagrams. This variable is set to true when the local PCS is configured to use the fast wake mechanism and set to false otherwise.

ram_counter_done
: Boolean variable that indicates that ram_counter has reached its terminal count.

ram_valid
: Boolean variable that is set to true when the 66-bit blocks concurrently received on at least 2 PCS lanes are valid Rapid Alignment Markers with identical values for rx_down_count and is set to false otherwise.

ram_valid_prev
: Boolean variable that holds the value of ram_valid from the previous expected Rapid Alignment Marker position.

ramps_counter_done
: Boolean variable that indicates that ramps_counter has reached its terminal count.

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ramps_valid
: Boolean variable that is set to true when the 64-bit block payloads concurrently received on at least 2 FEC lanes are valid Rapid Alignment Marker payloads with identical values for rx_down_count and is set to false otherwise.

ramps_valid_prev
: Boolean variable that holds that value of ramps_valid from the previous expected Rapid Alignment Marker payload position.

rx_down_count
: The value that results from the bit-wise exclusive-OR of the Count Down (CD_3) byte and the M_0 byte of the current Rapid Alignment Marker payload (see 82.2.9).

rx_lpi_active
: A Boolean variable that is set to true when the RS-FEC sublayer infers that the Low Power Idle is being received from the link partner and is set to false otherwise.

rx_quiet_timer_done
: A Boolean variable that indicates that rx_quiet_timer has reached its terminal count.

tx_down_count
: The value that results from the bit-wise exclusive-OR of the Count Down (CD_3) byte and the M_0 byte of the current Rapid Alignment Marker (see 82.2.9).

tx_lpi_active
: A Boolean variable that is set to true when the RS-FEC sublayer infers that the local PCS is transmitting Low Power Idle and is set to false otherwise.

tx_quiet_timer_done
: Boolean variable that indicates that tx_quiet_timer has reached its terminal count.

91.5.4.2.2 Functions

AMP_COMPARE
: This function compares the values of first_pcsl and current_pcsl to determine if a valid alignment marker payload sequence has been detected and returns the result of the comparison using the variable amp_match. When rx_lpi_active is false, if current_pcsl and first_pcsl are 0, amp_match is set to true. When rx_lpi_active is true, the comparison is performed as follows. If first_pcsl is 0 then amp_match is set to true if current_pcsl is 16. If first_pcsl is 16 then amp_match is set to true if current_pcsl is 0. Otherwise, amp_match is set to false.

SLIP
: Causes the next candidate block position to be tested. The precise method for determining the next candidate block position is not specified and is implementation dependent. However, an implementation shall ensure that all possible block positions are evaluated.

91.5.4.2.3 Counters

amp_counter
: When rx_lpi_active is false, this counter counts the 4096 FEC codewords that separate the ends of two consecutive normal alignment marker payload sequences. An FEC codeword is 1320 bits per FEC lane for 100GBASE-KR4 and 1360 bits per FEC lane for 100GBASE-KP4. When rx_lpi_active is true, then amp_counter is defined as follows. If first_pcsl corresponds to PCS lane 0, it counts the 256 bits to the end of the expected location of the Rapid Alignment Marker payload corresponding to PCS lane 16. If first_pcsl corresponds to PCS lane 16, this counter counts the 2 FEC codewords minus 256 bits to the end of the expected location of the next Rapid Alignment Marker payload corresponding to PCS lane 0.

cw_bad_count
: Counts the number of consecutive uncorrected FEC codewords. This counter is set to zero when an FEC codeword is received and cw_bad is false for that codeword.

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The following counters are only used for the optional EEE deep sleep capability.

1st_ram_counter
: This counter counts 4 66-bit blocks from the end of one candidate RAM position to the end of the next candidate RAM position. The first instance of the counter counts from the end of the last normal alignment marker received.

1st_ramps_counter
: This counter counts one FEC codeword from the end of one candidate RAM payload to the end of the next RAM payload position. An FEC codeword is 1320 bits per FEC lane for 100GBASE-KR4 and 1360 bits per FEC lane for 100GBASE-KP4

ram_counter
: This counter counts 8 66-bit blocks from the end of the current RAM to the end of the next expected RAM position.

ramps_counter
: This counter counts 2 FEC codewords from the end of the current RAM payload to the end of the next expected RAM payload position.

rx_quiet_timer
: This timer limits the maximum time fec_align_status may be deasserted before the Transmit LPI state diagram concludes that the link has failed. The value of this timer is between 2 ms and 2.8 ms.

tx_quiet_timer
: This timer limits the maximum time rx_align_status may be deasserted before the Transmit LPI state diagram concludes that the link has failed. The value of this timer is between 1.8 ms and 2 ms.

91.5.4.3 State diagrams

The FEC shall implement four synchronization processes as shown in Figure 91–8. The synchronization process operates independently on each lane. The synchronization state diagram determines when the FEC has detected the location of the alignment marker payload sequence in the received bit stream for a given lane of the service interface.

The FEC shall implement the alignment process as shown in Figure 91–9.

When the optional EEE deep sleep capability is supported, the FEC shall also implement the Transmit LPI process as shown in Figure 91–10 and the Receive LPI process as shown in Figure 91–11. The Transmit LPI state diagram infers when Low Power Idle is being transmitted by the local PCS by checking for the presence of Rapid Alignment Markers. The Receive LPI state diagram infers when Low Power Idle is being received from the link partner using a similar mechanism. Monitoring the position and frequency of alignment markers is also critical to the operation of the alignment marker removal function (see 91.5.2.4 and 91.5.3.4).

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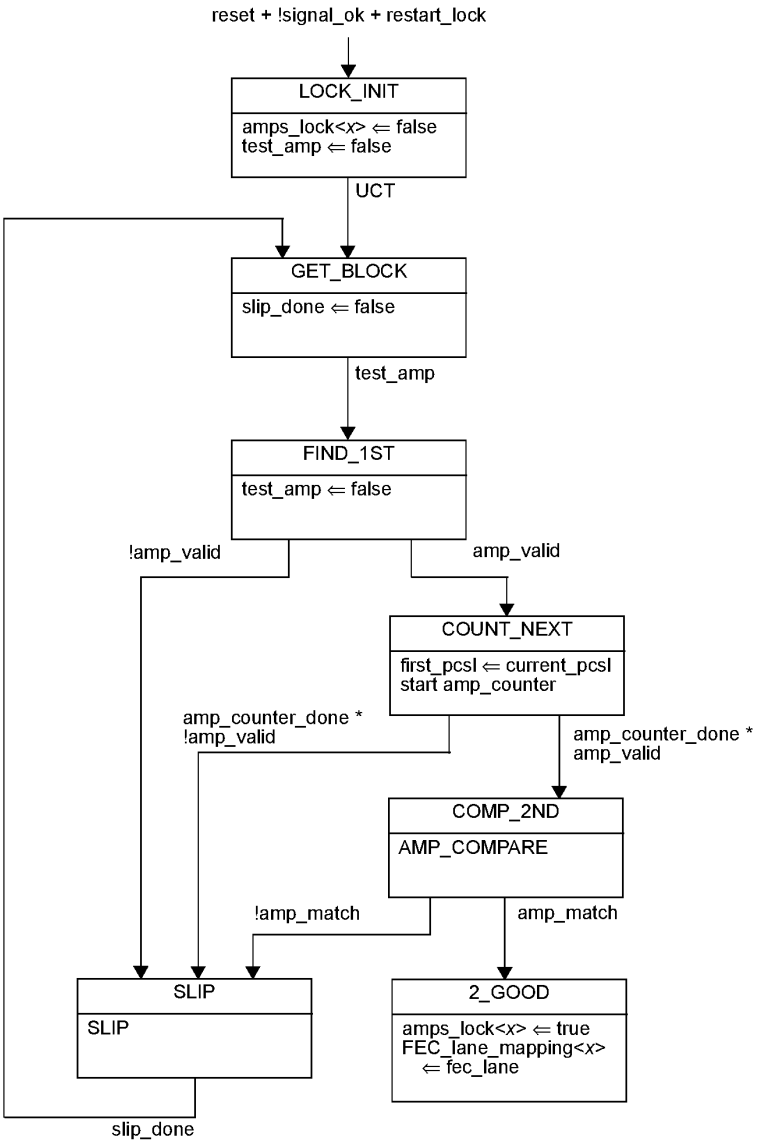


Figure 91–8—FEC synchronization state diagram

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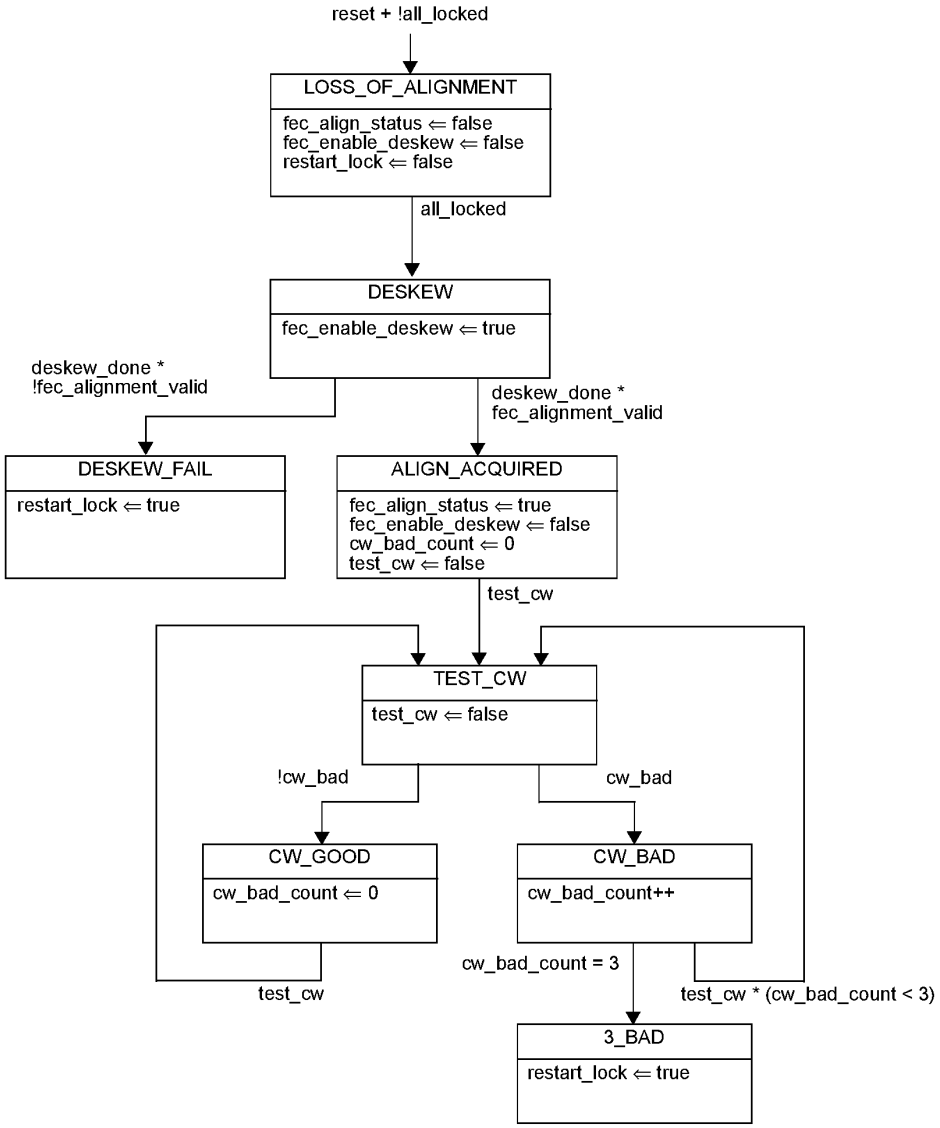


Figure 91–9—FEC alignment state diagram

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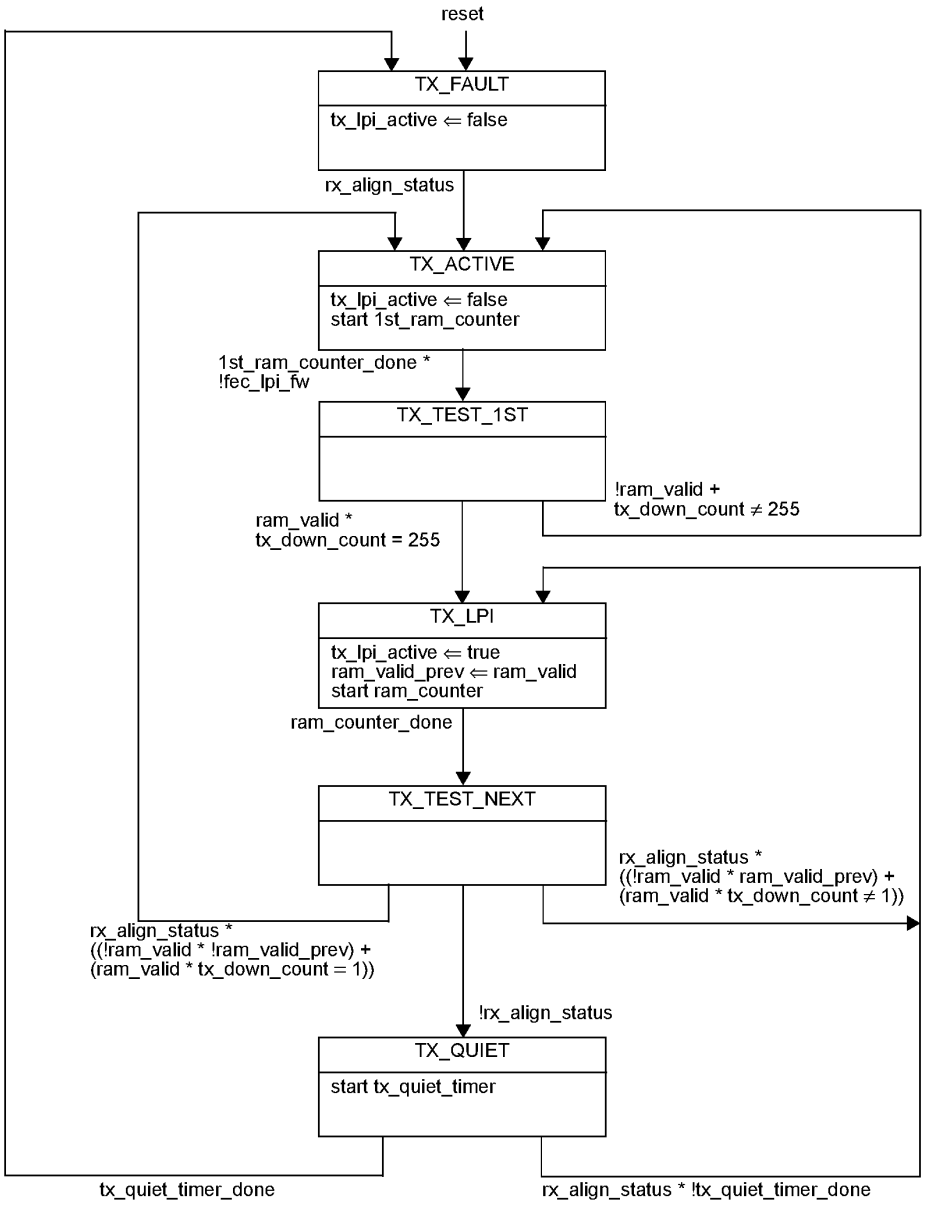


Figure 91–10—Transmit LPI state diagram

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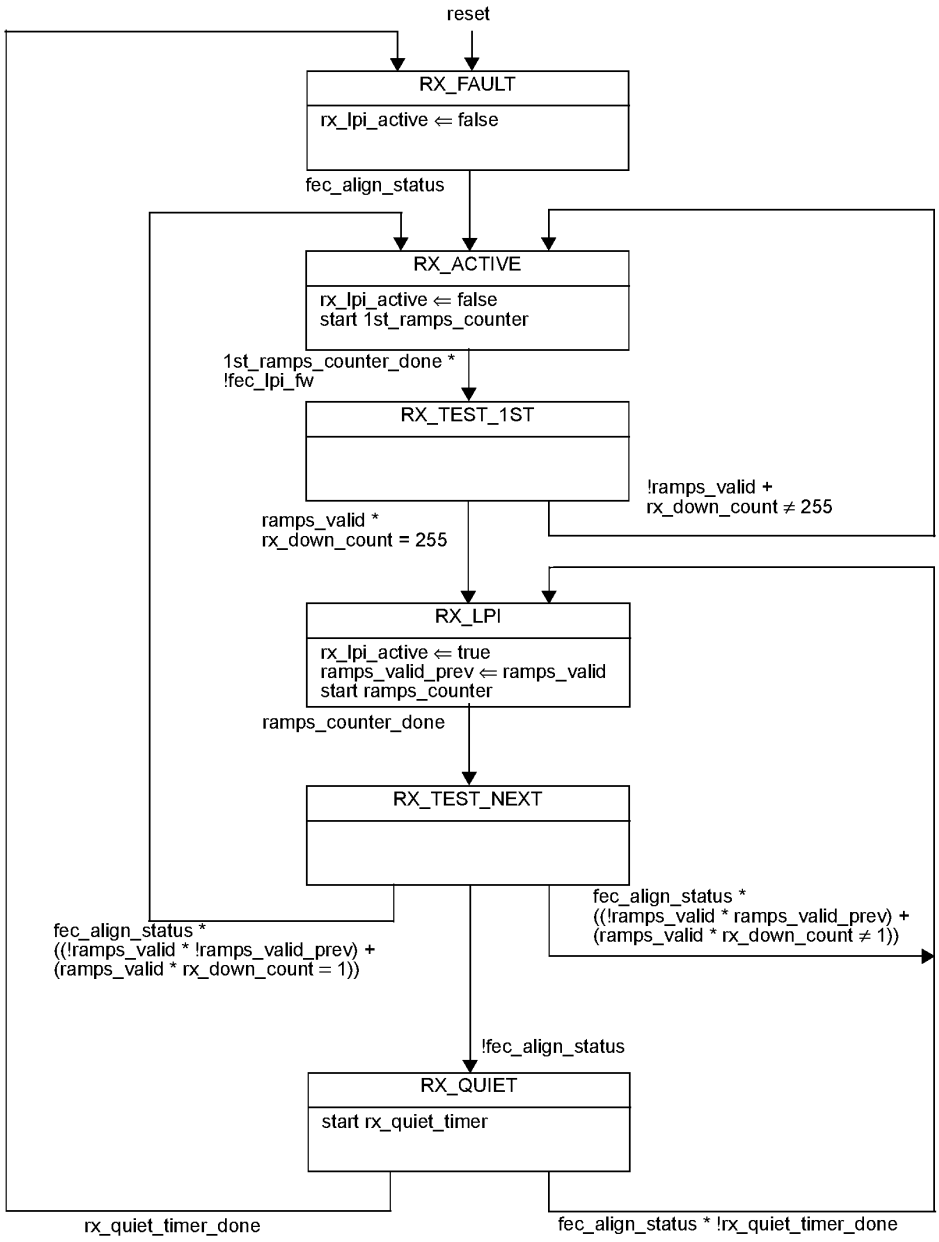


Figure 91–11—Receive LPI state diagram

91.6 RS-FEC MDIO function mapping

The optional MDIO capability described in Clause 45 defines several registers that provide control and status information for and about the RS-FEC. If MDIO is implemented, it shall map MDIO control bits to RS-FEC control variables as shown in Table 91–2, and MDIO status bits to RS-FEC status variables as

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shown in Table 91–3, and if a separated PMA (see 45.2.1) is connected to the FEC service interface it shall map additional MDIO status bits to additional RS-FEC status variables as shown in Table 91–4.

Table 91–2—MDIO/RS-FEC control variable mapping

MDIO control variable	PMA/PMD register name	Register/bit number	FEC variable
FEC bypass correction enable	RS-FEC control register	1.200.0	FEC_bypass_correction_enable
FEC bypass indication enable	RS-FEC control register	1.200.1	FEC_bypass_indication_enable

Table 91–3—MDIO/RS-FEC status variable mapping

MDIO control variable	PMA/PMD register name	Register/bit number	FEC variable
FEC bypass correction ability	RS-FEC status register	1.201.0	FEC_bypass_correction_ability
FEC bypass indication ability	RS-FEC status register	1.201.1	FEC_bypass_indication_ability
RS-FEC high SER	RS-FEC status register	1.201.2	hi_ser
FEC AM lock *x*, *x*=0 to 3	RS-FEC status register	1.201.8:11	amps_lock<*x*>
RS-FEC align status	RS-FEC status register	1.201.14	fec_align_status
FEC corrected codewords	RS-FEC corrected codewords counter register	1.202, 1.203	FEC_corrected_cw_counter
FEC uncorrected codewords	RS-FEC uncorrected codewords counter register	1.204, 1.205	FEC_uncorrected_cw_counter
FEC lane *x* mapping	RS-FEC lane mapping register	1.206	FEC_lane_mapping<*x*>
FEC symbol errors, FEC lanes 0 to 3	RS-FEC symbol error counter register, FEC lanes 0 to 3	1.210 to 1.217	FEC_symbol_error_counter_*i*

Table 91–4—MDIO/RS-FEC status variable mapping for separated PMA

MDIO control variable	PMA/PMD register name	Register/bit number	FEC variable
PCS align status	RS-FEC status register	1.201.15	align_status
BIP errors, PCS lanes 0 to 19	RS-FEC BIP error counter register, PCS lanes 0 to 19	1.230 to 1.249	BIP_error_counter_*i*
PCS lane *x* mapping	PCS lane *x* mapping register	1.250 to 1.269	lane_mapping<*x*>
Block *x* lock	RS-FEC PCS alignment status 1 and 2 registers	1.280 to 1.281	block_lock<*x*>
Lane *x* aligned	RS-FEC PCS alignment status 3 and 4 registers	1.282 to 1.283	am_lock<*x*>

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The following subclauses define variables that are not otherwise defined, e.g., for use by state diagrams.

91.6.1 FEC_bypass_correction_enable

When this variable is set to one, the Reed-Solomon decoder performs error detection without error correction (see 91.5.3.3). When this variable is set to zero, the decoder also performs error correction. The default value of the variable is zero. This variable is mapped to the bit defined in 45.2.1.101 (1.200.0).

91.6.2 FEC_bypass_indication_enable

This variable is set to one to bypass the error indication function (see 91.5.3.3) when this ability is supported. When this variable is set to zero, the decoder indicates errors to the PCS sublayer. This variable has no effect (the decoder does not bypass error indication) if FEC bypass correction enable (1.200.0) is set to one. The default value of this variable is zero. This variable is mapped to the bit defined in 45.2.1.101 (1.200.1).

91.6.3 FEC_bypass_correction_ability

The Reed-Solomon decoder may have the option to perform error detection without error correction (see 91.5.3.3) to reduce the delay contributed by the RS-FEC sublayer. This variable is set to one to indicate that the decoder has the ability to bypass error correction. The variable is set to zero if this ability is not supported. This variable is mapped to the bit defined in 45.2.1.102 (1.201.0).

91.6.4 FEC_bypass_indication_ability

The Reed-Solomon decoder may have the option to bypass the error indication function (see 91.5.3.3) to reduce the delay contributed by the RS-FEC sublayer. This variable is set to one to indicate that the decoder has the ability to bypass error indication. The variable is set to zero if this ability is not supported. This variable is mapped to the bit defined in 45.2.1.102 (1.201.1).

91.6.5 hi_ser

This variable is defined when the FEC_bypass_indication_ability variable is set to one. When FEC_bypass_indication_enable is set to one, this bit is set to one if the number of RS-FEC symbol errors in a window of 8192 codewords exceeds the threshold (see 91.5.3.3) and is set to zero otherwise. This variable is mapped to the bit defined in 45.2.1.102 (1.201.2).

91.6.6 amps_lock<*x*>

These variables are assigned by the FEC alignment state diagram shown in Figure 91–9 (see 91.5.4.3). They are mapped to the bits defined in 45.2.1.102 (1.201.8 to 1.201.11 for FEC lanes 0 to 3, respectively).

91.6.7 fec_align_status

This variable assigned by the FEC alignment state diagram shown in Figure 91–9 (see 91.5.4.3). It is mapped to the bit defined in 45.2.1.102 (1.201.14).

91.6.8 FEC_corrected_cw_counter

A corrected FEC codeword is a codeword that contains errors and was corrected.

FEC_corrected_cw_counter is a 32-bit counter that counts once for each corrected FEC codeword processed when fec_align_status is true. This variable is mapped to the registers defined in 45.2.1.103 (1.202, 1.203).

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91.6.9 FEC_uncorrected_cw_counter

An uncorrected FEC codeword is a codeword that contains errors (when the bypass correction feature is supported and enabled) or contains errors that were not corrected (when the bypass correction feature is not supported or not enabled).

FEC_uncorrected_cw_counter is a 32-bit counter that counts once for each uncorrected FEC codeword processed when fec_align_status is true. This variable is mapped to the registers defined in 45.2.1.104 (1.204, 1.205).

91.6.10 FEC_lane_mapping<*x*>

When the RS-FEC receive function detects and locks to an alignment marker payload on PMA service interface lane *x*, the FEC lane number corresponding to the detected alignment marker payload is assigned to the variable FEC_lane_mapping<*x*>. These variables are mapped to the register defined in 45.2.1.105 (1.206).

91.6.11 FEC_symbol_error_counter_*i*

FEC_symbol_error_counter_*i*, where *i*=0 to 3, is a 32-bit counter that counts once for each 10-bit symbol corrected on FEC lane *i* when fec_align_status is true. These variables are mapped to the registers defined in 45.2.1.106 and 45.2.1.107 (1.210 to 1.217).

91.6.12 align_status

This variable is assigned the value of rx_align_status as defined by the PCS deskew state diagram shown in Figure 82–14 (see 91.5.2.2). It is mapped to the bit defined in 45.2.1.102 (1.201.15).

91.6.13 BIP_error_counter_*i*

BIP_error_counter_*i*, where *i*=0 to 19, is a 16-bit counter that holds the BIP error count for PCS lane *i* as calculated by the RS-FEC transmit function (see 91.5.2.4). These variables are mapped to the registers defined in 45.2.1.108 and 45.2.1.109 (1.230 to 1.249).

91.6.14 lane_mapping<*x*>

When the RS-FEC transmit function detects and locks to an alignment marker on FEC service interface lane *x*, the PCS lane number corresponding to the detected alignment marker is assigned to the variable lane_mapping<*x*>. These variables are mapped to the registers defined in 45.2.1.110 and 45.2.1.111 (1.250 to 1.269).

91.6.15 block_lock<*x*>

These variables are assigned by the block lock state diagram shown in Figure 82–12 (see 91.5.2.1). They are mapped to the registers defined in 45.2.1.112 and 45.2.1.113 (1.280 to 1.281).

91.6.16 am_lock<*x*>

These variables are assigned by the alignment marker lock state diagram shown in Figure 82–13 (see 91.5.2.2). They are mapped to the registers defined in 45.2.1.114 and 45.2.1.115 (1.282 to 1.283).

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91.7 Protocol implementation conformance statement (PICS) proforma for Clause 91, Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 100GBASE-R PHYs[20]

91.7.1 Introduction

The supplier of a protocol implementation that is claimed to conform to Clause 91, Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 100GBASE-R PHYs, shall complete the following protocol implementation conformance statement (PICS) proforma.

A detailed description of the symbols used in the PICS proforma, along with instructions for completing the PICS proforma, can be found in Clause 21.

91.7.2 Identification

91.7.2.1 Implementation identification

Supplier[1]	
Contact point for inquiries about the PICS[1]	
Implementation Name(s) and Version(s)[1,3]	
Other information necessary for full identification—e.g., name(s) and version(s) for machines and/or operating systems; System Name(s)[2]	
NOTE 1— Required for all implementations. NOTE 2— May be completed as appropriate in meeting the requirements for the identification. NOTE 3—The terms Name and Version should be interpreted appropriately to correspond with a supplier's terminology (e.g., Type, Series, Model).	

91.7.2.2 Protocol summary

Identification of protocol standard	IEEE Std 802.3-2015, Clause 91, Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 100GBASE-R PHYs
Identification of amendments and corrigenda to this PICS proforma that have been completed as part of this PICS	
Have any Exception items been required? No [ ] Yes [ ] (See Clause 21; the answer Yes means that the implementation does not conform to IEEE Std 802.3-2015.)	

Date of Statement	

[20] *Copyright release for PICS proformas:* Users of this standard may freely reproduce the PICS proforma in this subclause so that it can be used for its intended purpose and may further publish the completed PICS.

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91.7.3 Major capabilities/options

Item	Feature	Subclause	Value/Comment	Status	Support
*KR4	100GBASE-CR4 or 100GBASE-KR4		Used to form complete 100GBASE-CR4 or 100GBASE-KR4 PHY	O	Yes [ ] No [ ]
*KP4	100GBASE-KP4		Used to form complete 100GBASE-KP4 PHY	O	Yes [ ] No [ ]
*SR4	100GBASE-SR4		Used to form complete 100GBASE-SR4 PHY	O	Yes [ ] No [ ]
DC	Delay constraints	91.4	Conforms to delay constraints specified in 91.4	M	Yes [ ]
*MD	MDIO capability	91.6	Registers and interface supported	O	Yes [ ] No [ ]
*BEC	Bypass error correction	91.5.3.3	Capability is supported	O	Yes [ ] No [ ]
*BEI	Bypass error indication	91.5.3.3	Capability is supported	O	Yes [ ] No [ ]
*EEE	EEE capability	91.5.4.3	Capability is supported	O	Yes [ ] No [ ]

91.7.4 PICS proforma tables for Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 100GBASE-R PHYs

91.7.4.1 Transmit function

Item	Feature	Subclause	Value/Comment	Status	Support
TF1	Skew tolerance	91.5.2.2	Maximum Skew of 49 ns between PCS lanes and a maximum Skew Variation of 400 ps	M	Yes [ ]
TF2	Lane reorder	91.5.2.3	Order the PCS lanes according to the PCS lane number	M	Yes [ ]
TF3	64B/66B to 256B/257B transcoder	91.5.2.5	tx_xcoded<256:0> constructed per 91.5.2.5	M	Yes [ ]
TF4	257-bit block transmission order	91.5.2.5	First bit transmitted is bit 0	M	Yes [ ]
TF5	Alignment maker mapping	91.5.2.6	Map to am_tx_mapped<1284:0> per 91.5.2.6	M	Yes [ ]
TF6	Pad value	91.5.2.6	Binary values 00101 and 11010 (the leftmost bit is assigned to the highest bit index) in an alternating pattern	M	Yes [ ]

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Item	Feature	Subclause	Value/Comment	Status	Support
TF7	Alignment marker insertion	91.5.2.6	First 1285 message bits to be transmitted from every 4096th codeword	M	Yes [ ]
TF8	Alignment marker insertion when tx_lpi_active is true	91.5.2.6	First 1285 message bits to be transmitted from every other codeword	EEE:M	Yes [ ] N/A [ ]
TF9	Alignment marker insertion point	91.5.2.6	First 257-bit block inserted after am_txmapped corresponds to the four 66-bit blocks received on PCS lanes 0, 1, 2, and 3 that immediately followed the alignment marker on each respective lane	M	Yes [ ]
TF10	Reed-Solomon encoder for 100GBASE-CR4 or 100GBASE-KR4 or 100GBASE-SR4	91.5.2.7	RS(528,514)	KR4:M or SR4:M	Yes [ ] N/A [ ]
TF11	Reed-Solomon encoder for 100GBASE-KP4	91.5.2.7	RS(544,514)	KP4:M	Yes [ ] N/A [ ]
TF12	Symbol distribution	91.5.2.8	Distributed to 4 FEC lanes, one 10-bit symbol at a time in a round robin distribution from the lowest to the highest numbered FEC lane	M	Yes [ ]

91.7.4.2 Receive function

Item	Feature	Subclause	Value/Comment	Status	Support
RF1	Skew tolerance	91.5.3.1	Maximum Skew of 180 ns between FEC lanes and a maximum Skew Variation of 4 ns	M	Yes [ ]
RF2	Lane reorder	91.5.3.2	Order the FEC lanes according to the FEC lane number	M	Yes [ ]
RF3	Reed-Solomon decoder for 100GBASE-CR4 or 100GBASE-KR4	91.5.3.3	Corrects any combination of up to t=7 symbol errors in a codeword unless error correction bypassed	KR4:M	Yes [ ] N/A [ ]
RF4	Reed-Solomon decoder for 100GBASE-KP4	91.5.3.3	Corrects any combination of up to t=15 symbol errors in a codeword unless error correction bypassed	KP4:M	Yes [ ] N/A [ ]
RF5	Reed-Solomon decoder for 100GBASE-SR4	91.5.3.3	Corrects any combination of up to t=7 symbol errors in a codeword	SR4:M	Yes [ ] N/A [ ]
RF6	Error correction bypass for 100GBASE-SR4	91.5.3.3	Error correction is not bypassed	SR4:M	Yes [ ] N/A [ ]

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Item	Feature	Subclause	Value/Comment	Status	Support
RF7	Reed-Solomon decoder	91.5.3.3	Capable of indicating when a codeword was not corrected.	M	Yes [ ]
RF8	Error indication function	91.5.3.3	Corrupts 66-bit block synchronization headers for uncorrected errored codewords (or errored codewords when correction is bypassed)	M	Yes [ ]
RF9	Error indication when error correction is bypassed	91.5.3.3	Error indication is not bypassed	BEI:M	Yes [ ] N/A [ ]
RF10	Error monitoring while error indication is bypassed	91.5.3.3	When the number of symbols errors in a block of 8192 codewords exceeds *K*, corrupt 66-bit block synchronization headers	BEI:M	Yes [ ] N/A [ ]
RF11	Symbol error threshold for 100GBASE-CR4, 100GBASE-KR4, and 100GBASE-SR4	91.5.3.3	*K*=417	BEI* KR4:M or BEI* SR4:M	Yes [ ] N/A [ ]
RF12	Symbol error threshold for 100GBASE-KP4	91.5.3.3	*K*=6380	BEI* KP4:M	Yes [ ] N/A [ ]
RF13	Error monitoring during LPI	91.5.3.3	Error monitor disabled when rx_lpi_active=true	BEI* EEE:M	Yes [ ] N/A [ ]
RF14	Start of error monitoring window	91.5.3.3	Begins on the codeword boundary following the transition of rx_lpi_active from true to false	BEI* EEE:M	Yes [ ] N/A [ ]
RF15	Alignment marker removal	91.5.3.4	am_rxmapped removed prior to transcoding	M	Yes [ ]
RF16	256B/257B to 64B/66B transcoder	91.5.3.5	rx_coded_*j*<65:0>, *j*=0 to 3 constructed per 91.5.3.5	M	Yes [ ]
RF17	Block distribution	91.5.3.6	One 66-bit block at a time in a round robin fashion from the lowest to the highest numbered PCS lane	M	Yes [ ]
RF18	Alignment marker mapping	91.5.3.7	Map to am_rx_*x*, *x*=0 to 19 per 91.5.3.7	M	Yes [ ]
RF19	Alignment marker insertion point	91.5.3.7	Alignment markers immediately followed by the 66-bit blocks derived from the 257-blocks immediately following am_rxmapped	M	Yes [ ]

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91.7.4.3 State diagrams

Item	Feature	Subclause	Value/Comment	Status	Support
SD1	SLIP function	91.5.4.2.2	Ensure that all possible block positions are evaluated	M	Yes [ ]
SD2	Synchronization process	91.5.4.3	One instance per FEC lane per Figure 91–8	M	Yes [ ]
SD3	Alignment process	91.5.4.3	Per Figure 91–9	M	Yes [ ]
SD4	Transmit LPI process	91.5.4.3	Per Figure 91–10	EEE:M	Yes [ ] N/A [ ]
SD5	Receive LPI process	91.5.4.3	Per Figure 91–11	EEE:M	Yes [ ] N/A [ ]

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EXAMINER
TAYONG, HELENE E

ART UNIT	PAPER NUMBER
2631	

DATE MAILED: 06/08/2018

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/487,045	04/13/2017	Junqing Sun	20160.0011.NPUS00	4720

TITLE OF INVENTION: LOW POWER SERDES ARCHITECTURE AND PROTOCOL

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0	$0	$500	09/10/2018

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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.

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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.

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(Signature)
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/487,045	04/13/2017	Junqing Sun	20160.0011.NPUS00	4720

TITLE OF INVENTION: LOW POWER SERDES ARCHITECTURE AND PROTOCOL

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$500	$0	$0	$500	09/10/2018

EXAMINER	ART UNIT	CLASS-SUBCLASS
TAYONG, HELENE E	2631	375-219000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/487,045	04/13/2017	Junqing Sun	20160.0011.NPUS00	4720

63467 7590 06/08/2018

Ramey & Schwaller, LLP
5020 Montrose Blvd.
Suite 750
Houston, TX 77006

EXAMINER	
TAYONG, HELENE E	
ART UNIT	**PAPER NUMBER**
2631	

DATE MAILED: 06/08/2018

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

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

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.

Marvell Semiconductor, Inc. - Ex. 1002, Page 000207

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).
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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. 15/487,045	Applicant(s) SUN ET AL.	
	Examiner HELENE TAYONG	Art Unit 2631	AIA (First Inventor to File) Status Yes

-- 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 *04/02/18*.
   ☐ 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 *1-20*. 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 _____
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 _____.

/HELENE TAYONG/
Primary Examiner, Art Unit 2631

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DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Response to Amendments

2. This Office Action is responsive to the Amendment filed on 04/02/2018. Claims 1-18, of which claims 1 and 11 are independent, were pending in this application and have been considered below.

3. Drawings objections are withdrawn in view of amendments to the claim**.**

4. Claim objections are withdrawn in view of the amendment**.**

5. Claim interpretation under 35 USC § 112 have been amendment (see Remark see pages 8-9, *applicant disagrees with the suggestion to add additional structure to the claim terms, as this would undesirably narrow the claim scope. Applicant submits that (at least in view of paragraph 16) those of ordinary skill in the art would understand the "module" terms*).

Allowable Subject Matter

6. Claims 1-20 are allowed.

7. As allowable subject matter has been indicated, applicant's reply must either comply with all formal requirements or specifically traverse each requirement not complied with. See 37 CFR 1.111(b) and MPEP § 707.07(a).

8. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled “Comments on Statement of Reasons for Allowance.”

9. The following is a statement of reasons for the indication of allowable subject matter:

The subject-matter of independent claims differs from the prior art, including **Kuan et al (US 9385859B2)** and **Akhter et al (US 8842721)**, in that the claims comprise a multi-lane communication method that comprises, in a transceiver: receiving receive signals on different receive channels; converting each of the receive signals into a lane of a multi-lane receive data stream, wherein said converting includes demodulation and error measurement; determining remote pre-equalizer adaptation information based at least in part on the error measurement; using alignment markers in each lane of the multi-lane receive data stream to align the lanes: extracting local pre-equalizer adaptation information from the multi-lane receive data stream, said adaptation information being included in, or proximate to, the alignment markers in at least one lane of the multi-lane receive data stream; using the local pre-equalizer

adaptation information to adjust one or more coefficients of a local pre-equalization filter.

Addressing each independent claim separately

Regarding claim 1, the prior arts made of record fail to teach or suggest or make obvious in combination, the arrangement that **"***in a transceiver: receiving receive signals on different receive channels; converting each of the receive signals into a lane of a multi-lane receive data stream, wherein said converting includes demodulation and error measurement; determining remote pre-equalizer adaptation information based at least in part on the error measurement; using alignment markers in each lane of the multi-lane receive data stream to align the lanes: extracting local pre-equalizer adaptation information from the multi-lane receive data stream, said adaptation information being included in, or proximate to, the alignment markers in at least one lane of the multi-lane receive data stream; using the local pre-equalizer adaptation information to adjust one or more coefficients of a local pre-equalization filter;***"*,* **in combination with** "periodically inserting an alignment marker in each lane of a multi-lane transmit data stream, wherein the remote pre-equalizer adaption information is included in, or inserted proximate to, the alignment markers in at least one lane of the multi-lane transmit data stream; transforming each lane of the multi-lane transmit data stream into a transmit signal, wherein said transforming includes modulating and further includes applying the local pre-equalization filter; and transmitting the transmit signals on different transmit channels.." in order to form "A MULTI-LANE COMMUNICATION

METHOD", and further limitation of their respective dependent claims 2-10, correspondingly.

Regarding claim 11, the prior arts made of record fail to teach or suggest or make obvious in combination, the arrangement that **"***multiple receivers, each receiver receiving and demodulating a receive signal from a corresponding receive channel to provide a data stream corresponding to one lane of a multi-lane receive data stream; one or more adaptation modules that derive error measurements from the receive signals and responsively determine remote pre-equalizer adaptation information; a deskew module that uses alignment markers in each lane of the multi-lane receive data stream to align the lanes; one or more extraction modules that extract local pre-equalizer adaptation information from the multi-lane receive data stream, said adaptation information being included in, or proximate to, the alignment markers in at least one lane of the multi-lane receive data stream; one or more training controllers that update coefficients of local pre-equalization filters using the local pre-equalizer adaptation information;***"*, **in combination with** "an alignment marker insertion module that periodically inserts an alignment marker in each lane of a multi-lane transmit data stream, wherein the remote pre-equalizer adaption information is included in, or inserted proximate to, the alignment markers in at least one lane of the multi-lane transmit data stream; multiple transmitters, each transmitter modulating a data stream corresponding

to one lane of the multi-lane transmit data stream and applying one of said local preequalization filters to provide a transmit signal to a corresponding transmit channel." **in order to form** "A COMMUNICATIONS TRANSCEIVER**"**, and further limitation of their respective dependent claims 12-20, correspondingly.

Conclusion

10. Any inquiry concerning this communication or earlier communications from the examiner should be directed to HELENE TAYONG whose telephone number is (571)270-1675. The examiner can normally be reached on Monday-Friday 8:00 am to 5:30 pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Liu Shuwang can be reached on 571-272-3036. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may 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). If you would like assistance from a USPTO Customer Service Representative or access to the

automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/HELENE TAYONG/
Primary Examiner, Art Unit 2631
May 29, 2018

Notice of References Cited	Application/Control No. 15/487,045	Applicant(s)/Patent Under Reexamination SUN ET AL.	
	Examiner HELENE TAYONG	Art Unit 2631	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-2012/0044951 A1	02-2012	Han; Kyeong Eun	H04L69/323	370/419
*	B	US-2016/0337114 A1	11-2016	BADEN; Eric	H04J3/0697	1/1
	C	US-				
	D	US-				
	E	US-				
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC 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.

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

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	15487045
Filing Date	2017-04-13
First Named Inventor	Junqing Sun
Art Unit	2631
Examiner Name	Helene E. Tayong
Attorney Docket Number	20160.0011.NPUS00

U.S.PATENTS

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					

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

U.S.PATENT APPLICATION PUBLICATIONS

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	20130343400	A1	2013-12-26	Lusted et al.	
	2	20140086264	A1	2014-03-37	Lusted et al.	
	3	20140146833	A1	2014-05-29	Lusted et al.	

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

FOREIGN PATENT DOCUMENTS

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							☐

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /H.E.T/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15487045
	Filing Date	2017-04-13
	First Named Inventor	Junqing Sun
	Art Unit	2631
	Examiner Name	Helene E. Tayong
	Attorney Docket Number	20160.0011.NPUS00

	2							☐

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

NON-PATENT LITERATURE DOCUMENTS

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	International Search Report and Written Opinion dated December 6, 2017, in International Application No. PCT/CN17/75961.	☐
	2	"Physical Medium Attachment (PMA) sublayer, Physical Medium Dependent (PMD) sublayer, and baseband medium, type 100GBASE-KP4," IEEE Standard for Ethernet, Section Six, pp. 481-519, 33 pgs.	☐
	3	"Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model", IEEE International Standard, Second Edition Corrected and Reprinted, June 15, 1996, 68 pgs.	☐

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

EXAMINER SIGNATURE

Examiner Signature	/HELENE E TAYONG/	Date Considered	05/29/2018

*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.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /H.E.T/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	15487045
Filing Date	2017-04-13
First Named Inventor	Junqing Sun
Art Unit	2631
Examiner Name	Helene E. Tayong
Attorney Docket Number	20160.0011.NPUS00

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.

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

☐ None

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	/Daniel J. Krueger/	Date (YYYY-MM-DD)	2018-03-21
Name/Print	Daniel J. Krueger	Registration Number	42,771

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.**

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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.

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.

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /H.E.T/

Marvell Semiconductor, Inc. - Ex. 1002, Page 000220

94. Physical Medium Attachment (PMA) sublayer, Physical Medium Dependent (PMD) sublayer, and baseband medium, type 100GBASE-KP4

94.1 Overview

This clause specifies the Physical Medium Attachment (PMA) sublayers, Physical Medium Dependent (PMD) sublayer, and medium for the 100GBASE-KP4 PHY.

When forming a complete Physical Layer, the PMA shall be connected to the RS-FEC, the PMD shall be connected to the medium through the MDI as shown in Figure 94–1, and the PMA and PMD shall be connected to the management functions that are optionally accessible through the management interface defined in Clause 45, or equivalent.

Table 94–1—Physical Layer clauses associated with the 100GBASE-KP4 PMD

Associated clause	100GBASE-KP4
81—RS	Required
81—CGMII[a]	Optional
82—PCS for 100GBASE-R	Required
83—PMA for 100GBASE-R	Optional
83A—CAUI-10	Optional
83D—CAUI-4	Optional
91—RS-FEC	Required
73—Auto-Negotiation	Required
78—Energy-Efficient Ethernet	Optional

[a]The CGMII is an optional interface. However, if the CGMII is not implemented, a conforming implementation must behave functionally as though the RS and CGMII were present.

Figure 94–1 shows the relationship of the 100GBASE-KP4 PMA and PMD sublayers and MDI to the ISO/IEC Open System Interconnection (OSI) reference model.

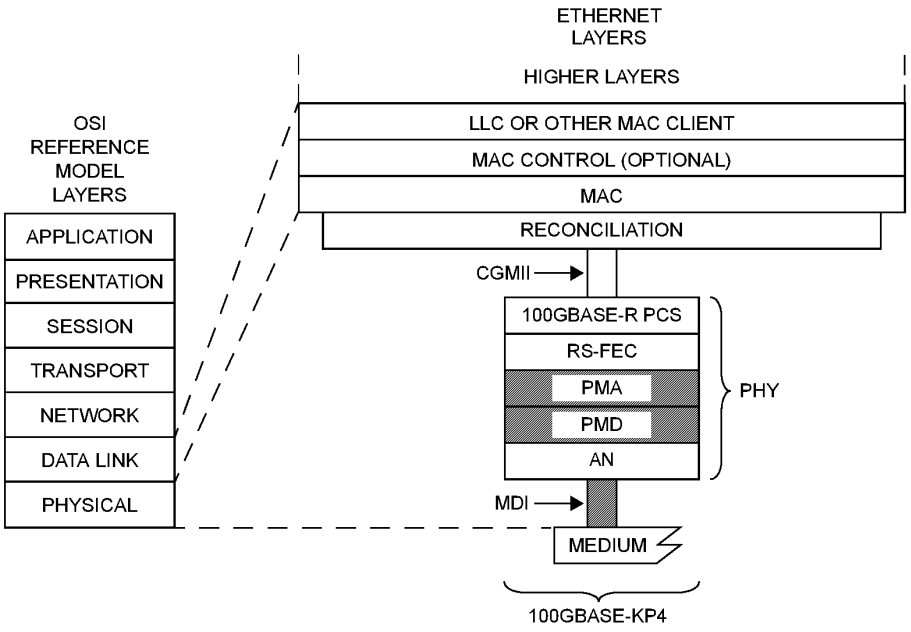
Differential signals received at the MDI from a transmitter that meets the requirements of 94.2.2 and 94.3.12 and have passed through the channel specified in 94.4 are received with a BER less than 10^{-5} as measured at the PMA service interface.

For a complete Physical Layer, this specification is considered to be satisfied by a frame loss ratio (see 1.4.223) of less than 6.2×10^{-10} for 64-octet frames with minimum interpacket gap.

A 100GBASE-KP4 PHY with the optional Energy-Efficient Ethernet (EEE) capability may optionally enter the Low Power Idle (LPI) mode to conserve energy during periods of low link utilization.

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AN = AUTO-NEGOTATION
CGMII = 100 Gb/s MEDIA INDEPENDENT INTERFACE
LLC = LOGICAL LINK CONTROL
MAC = MEDIA ACCESS CONTROL
MDI = MEDIUM DEPENDENT INTERFACE
PCS = PHYSICAL CODING SUBLAYER
PHY = PHYSICAL LAYER DEVICE
PMA = PHYSICAL MEDIUM ATTACHMENT
PMD = PHYSICAL MEDIUM DEPENDENT
RS-FEC = REED-SOLOMON FORWARD ERROR CORRECTION

Figure 94–1—100GBASE-KP4 PMA and PMD relationship to the ISO/IEC Open Systems Interconnection (OSI) reference model and the IEEE 802.3 Ethernet model

94.2 Physical Medium Attachment (PMA) Sublayer

94.2.1 PMA Service Interface

The PMA service interface for 100GBASE-KP4 PMA is based on the inter-sublayer service interface defined in 80.3. This interface is defined in an abstract manner and does not imply any particular implementation.

The PMA service interface primitives are summarized as follows:

PMA:IS_UNITDATA_*i*.request
PMA:IS_UNITDATA_*i*.indication
PMA:IS_SIGNAL.indication

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If the optional EEE deep sleep capability is supported (see Clause 78, 78.1.3.3.1), then the PMA service interface includes four additional primitives as follows:

PMA:IS_TX_MODE.request
PMA:IS_RX_MODE.request
PMA:IS_ENERGY_DETECT.indication
PMA:IS_RX_TX_MODE.indication

94.2.1.1 PMA:IS_UNITDATA_i.request

The PMA:IS_UNITDATA_*i*.request (where *i*=0 to 3) primitive is used to define the transfer of four streams of data units from the PMA client to the PMA.

94.2.1.1.1 Semantics of the service primitive

PMA:IS_UNITDATA_0.request(tx_bit,start)
PMA:IS_UNITDATA_1.request(tx_bit,start)
PMA:IS_UNITDATA_2.request(tx_bit,start)
PMA:IS_UNITDATA_3.request(tx_bit,start)

The data conveyed by PMA:IS_UNITDATA_0.request to IS_UNITDATA_3.request consists of four parallel continuous streams of encoded bits, one stream for each lane. Each of the tx_bit parameters can take one of two values: one or zero. The start parameter is TRUE to indicate that the concurrent tx_bit is the first bit of the first, second, third, or fourth FEC symbol in a FEC codeword and is otherwise FALSE.

94.2.1.1.2 When generated

The PMA client continuously sends four parallel bit streams PMA:IS_UNITDATA_*i*.request(tx_bit,start) to the PMA, each at a nominal signaling rate of 26.5625 Gb/s.

94.2.1.1.3 Effect of receipt

Upon receiving each instance of PMA:IS_UNITDATA_*i*.request, the tx_bit and start parameters are passed to the PMA framing process corresponding to each stream.

94.2.1.2 PMA:IS_UNITDATA_i.indication

The PMA:IS_UNITDATA_*i*.indication (where *i* = 0 to 3) primitive is used to define the transfer of four streams of data units from the PMA to the PMA client.

94.2.1.2.1 Semantics of the service primitive

PMA:IS_UNITDATA_0.indication(rx_bit, start)
PMA:IS_UNITDATA_1.indication(rx_bit, start)
PMA:IS_UNITDATA_2.indication(rx_bit, start)
PMA:IS_UNITDATA_3.indication(rx_bit, start)

The data conveyed by PMA:IS_UNITDATA_0.indication to PMA:IS_UNITDATA_3.indication consists of four parallel continuous streams of encoded bits, one stream for each lane. Each of the rx_bit parameters can take one of two values: one or zero. The start parameter is TRUE to indicate that the concurrent rx_bit is the first bit of the first, second, third, or fourth FEC symbol in the FEC codeword and is otherwise FALSE.

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94.2.1.2.2 When generated

The PMA continuously sends four parallel bit streams PMA:IS_UNITDATA_*i*.indication(rx_bit,start) to the PMA client, each at a nominal signaling rate of 26.5625 Gb/s.

94.2.1.2.3 Effect of receipt

The effect of receipt of this primitive is defined by the PMA client.

94.2.1.3 PMA:IS_SIGNAL.indication

The PMA:IS_SIGNAL.indication primitive is generated by the PMA to the PMA client to indicate the status of the receive process. This primitive is generated by the receive process to propagate the detection of severe error conditions (e.g., loss of synchronization) to the PMA client.

94.2.1.3.1 Semantics of the service primitive

PMA:IS_SIGNAL.indication(SIGNAL_OK)

The SIGNAL_OK parameter can take on one of two values: OK or FAIL. A value of FAIL denotes that invalid data is being presented (rx_bit parameters undefined) by the PMA to the PMA client. A value of OK does not guarantee valid data is being presented by the PMA to the PMA client.

94.2.1.3.2 When generated

The PMA generates the PMA:IS_SIGNAL.indication primitive to the PMA client whenever there is a change in the value of the SIGNAL_OK parameter.

94.2.1.3.3 Effect of receipt

The effect of receipt of this primitive is defined by the PMA client.

94.2.1.4 PMA:IS_TX_MODE.request

The PMA:IS_TX_MODE.request primitive communicates the tx_mode parameter generated by the PCS LPI transmit process to invoke the appropriate PMA, FEC, and PMD transmit EEE states. Without EEE deep sleep capability, this primitive is never invoked and the sublayers behave as if tx_mode = DATA.

94.2.1.4.1 Semantics of the service primitive

PMA:IS_TX_MODE.request(tx_mode)

The tx_mode parameter takes on one of up to three values: DATA, QUIET, or ALERT.

94.2.1.4.2 When generated

This primitive is generated to indicate the state of the PCS LPI transmit function.

94.2.1.4.3 Effect of receipt

When this primitive is received, PMD:IS_TX_MODE.request(tx_mode) is generated with the value received in PMA:IS_TX_MODE.request(tx_mode).

If the value is DATA or ALERT, the PMA operates normally.

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If the value is QUIET, the PMA may go into a low power mode.

94.2.1.5 PMA:IS_RX_MODE.request

The PMA:IS_RX_MODE.request primitive communicates the rx_mode parameter generated by the PCS LPI receive process. Without EEE deep sleep capability, this primitive is never invoked and the sublayers behave as if rx_mode = DATA.

94.2.1.5.1 Semantics of the service primitive

PMA:IS_RX_MODE.request(rx_mode)

The rx_mode parameter takes on one of two values: DATA or QUIET.

94.2.1.5.2 When generated

This primitive is generated to indicate the state of the PCS LPI receive function.

94.2.1.5.3 Effect of receipt

When this primitive is received, PMD:IS_RX_MODE.request(rx_mode) is generated with the value received in PMA:IS_RX_MODE.request(rx_mode).

If the value is DATA, the PMA operates normally.

If the value is QUIET, the PMA may be go into a low power mode.

94.2.1.6 PMA:IS_ENERGY_DETECT.indication

The PMA:IS_ENERGY_DETECT.indication primitive is used to communicate that the PMD has detected the presence of energy on the interface following a period of quiescence. Without EEE deep sleep capability, this primitive is never invoked and has no effect.

94.2.1.6.1 Semantics of the service primitive

PMA:IS_ENERGY_DETECT.indication(energy_detect)

The parameter energy_detect is Boolean.

94.2.1.6.2 When generated

This primitive is generated by the PMA, reflecting the state of PMD:IS_SIGNAL.indication(SIGNAL_OK) received from the PMD (see 94.3.1.3). When SIGNAL_OK indicates OK, energy detect indicates TRUE. When SIGNAL_OK indicates FAIL, energy_detect indicates FALSE.

94.2.1.6.3 Effect of receipt

The effect of receipt of this primitive is defined by the PMA client sublayers that receive it.

94.2.1.7 PMA:IS_RX_TX_MODE.indication

The PMA:IS_RX_TX_MODE.indication primitive communicates the value of the rx_tx_mode parameter. This parameter indicates the value of tx_mode that the PMA sublayer has inferred from the received signal.

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Without EEE deep sleep capability, the primitive is never generated and the sublayers behave as if rx_tx_mode=DATA.

94.2.1.7.1 Semantics of the service primitive

PMA:IS_RX_TX_MODE.indication(rx_tx_mode)

The parameter rx_tx_mode is assigned one of the following values: DATA, QUIET, or ALERT. DATA is assigned when the PMA is reset or when PMA frames are being received. QUIET is assigned if PMA frame reception ceases. ALERT is assigned if rx_tx_mode = QUIET and PMD:IS_SIGNAL.indication(SIGNAL_OK) transitions from FAIL to OK.

94.2.1.7.2 When generated

This primitive is generated whenever there is change in the value of the rx_tx_mode parameter.

94.2.1.7.3 Effect of receipt

The RS-FEC sublayer passes this primitive through to the PMA sublayer that may exist above.

94.2.2 PMA Transmit Functional Specifications

In the transmit direction, the role of the 100GBASE-KP4 PMA is to adapt the signal from the FEC (the PMA client) to a PAM4 encoded signal to be passed to the PMD for transfer over the attached medium. The adaptation processes shown in Figure 94–2 include insert overhead, insert termination bits, apply Gray coding, apply 1/(1+D) mod 4 precoding, and apply PAM4 encoding.

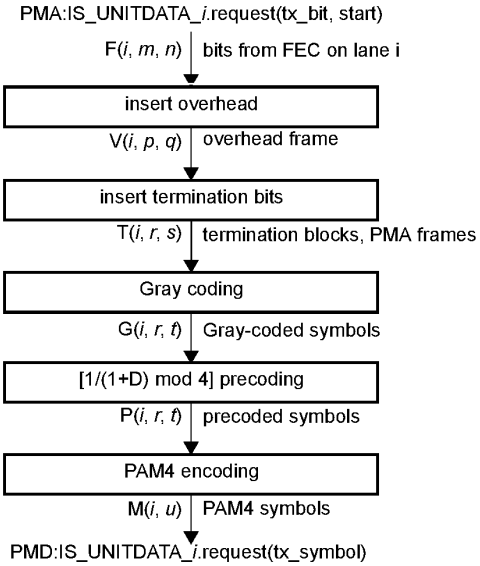


Figure 94–2—Transmit adaptation process diagram

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94.2.2.1 FEC Interface

The PMA transmit process receives FEC bits via the PMA:IS_UNITDATA_*i*(tx_bit, start) primitive (see 94.2.1.1). The index *i* indicates the PMA lane number: 0, 1, 2, or 3.

On each transaction, tx_bit is assigned to F(*i*, *m*, *n*), where

i is the lane number
m is an index indicating the FEC codeword number and increments at the start of each codeword
n is an index indicating the bit number within a codeword with a range 1 to 1360

The start of a codeword is determined by the start parameter associated with the tx_bit parameter being equal to TRUE.

94.2.2.2 Overhead Frame

The PMA transmit process shall create a sequence of overhead frames by inserting 40 overhead bits for every 31280 FEC bits as specified in this subclause.

The FEC bits, F(*i*, *m*, *n*), are mapped into a continuous sequence of overhead frames. The overhead frame is 31320 bits in length.

Each bit in the overhead frame is denoted V(*i*, *p*, *q*), where:

i is the lane number
p is an index that indicates the frame number and increments at the start of each frame
q is an index that indicates the bit number within a frame with a range 1 to 31320

The first 40 bits of the frame, V(*i*, *p*, 1) to V(*i*, *p*, 40), are the overhead bits (see 94.2.2.3). The next 31280 bits, V(*i*, *p*, 41) to V(*i*, *p*, 31320), are composed of the bits from 23 consecutive FEC codewords.

The overhead bits are inserted in the frame as follows:

V(*i*, *p*, 1) = H(*i*, *p*, 1)
V(*i*, *p*, 2) = H(*i*, *p*, 2)
V(*i*, *p*, ...) = H(*i*, *p*, ...)
V(*i*, *p*, 40) = H(*i*, *p*, 40)

The FEC codeword bits are aligned such that V(*i*, *p*, 41) is the first bit of a codeword, e.g., V(*i*, *p*, 41) = F(*i*, *m*, 1). The FEC bits are inserted into the frame in the order in which they were received from the FEC, e.g., V(*i*, *p*, 42) = F(*i*, *m*, 2), V(*i*, *p*, 43) = F(*i*, *m*, 3), and so on. The method for aligning the FEC codeword with the start of the overhead frame is outside the scope of this standard.

94.2.2.3 Overhead

The PMA transmit process shall form the overhead bits in each overhead frame as specified in this subclause.

The overhead bits are denoted H(*i*, *p*, *k*), where

i is the lane number
p is an index that indicates the frame number and increments at the start of each frame
k is an index that indicates the header bit number with a range 1 to 40

Bits are mapped to the overhead in a sequence of five groups of 8 bits each. Each 8-bit group takes on the value A or An. The values of the 8 bits in A are such that A(7:0) = TX_OH_pattern(7:0). The values of the 8 bits in An are such that each bit is the inverse of the corresponding bit in A. For each lane i, the sequence

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of 8-bit groups is according to the bits in TX_OH_sequence_i(4:0) such that H(*i*,*p*,((*a*+1)*8):(*a*8+1)) is equal to A(7:0) or An(7:0) if TX_OH_sequence_i(*a*) is equal to 0 or 1, respectively, where a ∈ {0,1,2,3,4}.

If the optional Clause 45 MDIO is implemented, the overhead function maps the TX_OH_pattern and TX_OH_sequence_i status variables to the registers and bits defined in 94.2.10. The default values for each of the variables are summarized in Table 94–2.

Table 94–2—Default overhead configuration values

Parameter	Values (binary)
TX_OH_pattern(7:0)	01100110
TX_OH_sequence_0(4:0)	00110
TX_OH_sequence_1(4:0)	01010
TX_OH_sequence_2(4:0)	10101
TX_OH_sequence_3(4:0)	11001

94.2.2.4 Termination Blocks

The PMA transmit process shall create a sequence of termination blocks by inserting two termination bits for every 90 overhead frame bits as specified in this subclause. The termination block is 92 bits in length. The overhead frame mapped into 348 consecutive termination blocks forms a PMA frame.

Each bit in a termination block is denoted T(*i*, *r*, *s*), where:

i is the lane number
r is an index indicating block number and increments at the start of each block
s is an index indicating the bit number within a termination block with a range 1 to 92

The first two bits in each termination block, T(*i*, *r*, 1) and T(*i*, *r*, 2), are populated with the output of a PRBS13 generator of the form specified in 94.3.10.8. For each termination block, the PRBS13 generator generates a block of 92 pseudo-random bits, R(*i*,1:92). The first two bits are used for the termination bits such that T(*i, r,* 1)=R(*i*, 1) and T(*i, r*, 2)=R(*i*, 2). The PRBS13 generator is initialized during training (94.3.10.8). Upon the transition from the last training frame to the first PMA frame the PRBS13 generator used during training advances without reseeding (see 94.3.10.7.2) and without inversion, and the output is used to generate the termination bits. The PRBS13 generator continues to advance without reseeding and without inversion.

The remaining 90 bits of each termination block, T(*i*, *r*, 3) to T(*i*, *r*, 92), are overhead frame bits (see 94.2.2.2). The overhead frame bits are aligned with the termination blocks such that the first overhead bit, V(*i*, *p*, 1), corresponds to the third bit of a termination block, T(*i*, *r*, 3).

Overhead frame bits are mapped to the termination blocks in order of location within the overhead frame, e.g., T(*i*, *r*, 4) = V(*i*, *p*, 2), T(*i*, *r*, 5) = V(*i*, *p*, 3), and so on.

The termination bit PRBS13 generator is initialized during the training process. When training is complete the state of the termination bit PRBS13 generator is retained and the resulting output is used for the termination bits in the PMA frame.

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94.2.2.5 Gray Mapping

The PMA transmit process shall map consecutive pairs of bits to one of four Gray-coded symbols as specified in this subclause.

Each pair of bits, {A, B}, of each termination block are converted to a Gray-coded symbol with one of the four Gray-coded levels as follows:

{0, 0} maps to 0,
{0, 1} maps to 1,
{1, 1} maps to 2, and
{1, 0} maps to 3.

Gray-coded symbols corresponding to each termination block are denoted G(i, r, t), where:

i is the lane number
r is an index indicating the termination block number
t is an index indicating the symbol number within a termination block with a range 1 to 46

Pairing of bits is such that the first two bits of each termination block, T(i, r, 1) and T(i, r, 2), form a pair. Each bit pair {T(i, r, 2t–1), T(i, r, 2t)} maps to {A, B} and the Gray-coded result is assigned to G(i, r, t). The Gray-coded symbol G(i, r, 1) is formed from the first two bits of a termination block, the termination bits, thus forming a termination symbol.

94.2.2.6 Precoding

The PMA transmit process shall precode the Gray-coded symbols as specified in this subclause.

The precoder output symbols are denoted, P(i, r, t), where:

i is the lane number
r is an index indicating the termination block number
t is an index indicating the symbol number within a termination block with a range 1 to 46.

For each Gray-coded symbol G(i, r, t), a precoded symbol, P(i, r, t) is determined by the following algorithm:

If t = 1 then
    P(i, r, t) = G(i, r, t)
Else
    P(i, r, t) = (G(i, r, t) – P(i, r, t–1)) mod 4
End If

The bits contributing to the Gray-coded termination symbol, G(i, r, 1), are the termination bits. The precoding algorithm applies this symbol directly to the output rather than combining it with the previous non-deterministic symbols and thus this termination symbol is always deterministic.

94.2.2.7 PAM4 encoding

The PMA transmit process shall encode each precoder output symbol to one of four PAM4 levels as specified in this subclause.

The PAM4 encoded symbols are denoted M(i, u), where

i is the lane number
u is an index indicating the symbol number

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Each consecutive precoder output symbol, P(*i*, *r*, *t*), is mapped to one of four PAM4 levels and assigned to the PAM4 encoder output M(*i*, u).

Mapping from the precoder output symbol P(*i*, *r*, *t*) to a PAM4 encoded symbol M(*i*, *u*) is as follows:

0 maps to –1,
1 maps to –1/3,
2 maps to +1/3, and
3 maps to +1.

94.2.2.8 PMD Interface

The PMA transmit process shall transmit each PAM4 encoded symbol, M(*i*, *u*) to the PMD via the PMD:IS_UNITDATA_*i*(tx_symbol) primitive at a symbol transfer rate of 13.59375 GBd.

94.2.3 PMA Receive Functional Specifications

The receive process shall recover the data encoded by the transmit process meeting the performance requirements specified in 94.1 after the overhead and termination bits have been removed.

The process by which the receiver recovers the data to meet this requirement is outside the scope of this standard. The signal structure encoded by the transmitter process including the overhead bits, Gray coding, and termination symbols may be leveraged by the receiver implementation at the discretion of the implementer. The remainder of this subclause specifies the receiver processes to reverse the transmitter encoding and report status.

In the received direction, the role of the 100GBASE-KP4 PMA is to adapt the PAM4 encoded signal from the PMD to a FEC encoded signal to be passed to the FEC for further processing. The adaptation processes shown in Figure 94–3 include PAM4 decoding, (1+D) mod 4 decoding, inverse Gray coding, remove termination bits, and remove overhead.

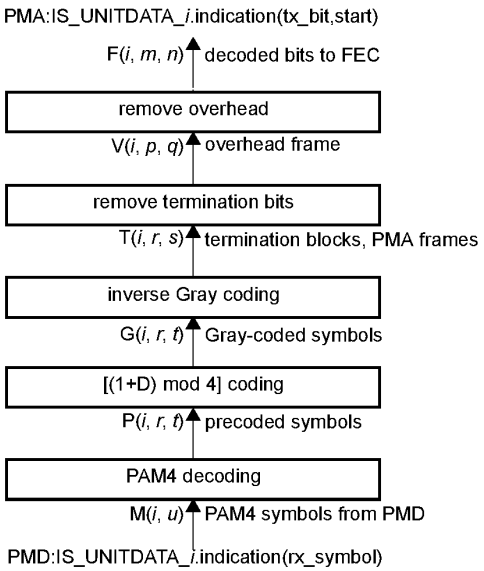


Figure 94–3—Receive adaptation process diagram

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94.2.3.1 Overhead

The PMA receive process shall decode the overhead bits in each overhead frame as specified in this subclause. The format of the overhead bits is specified in 94.2.2.3.

The receive process decodes the received overhead bits in a sequence of five groups of 8 bits each into a sequence of 5 bits. Each group of 8 bits is compared with A and An, where A(7:0) = RX_OH_pattern(7:0) and the values of the 8 bits in An are such that each bit is the inverse of the corresponding bit in A. A match of each 8-bit group with A or An results in a decoded value of 0 or 1, respectively. The decoded value when the 8-bit group matches neither A or An is not specified. The decoded values from H(i,p,((a+1)*8):(a*8+1)) are assigned to RX_OH_sequence_i(a), where $a \in \{0,1,2,3,4\}$. If all of the 8-bit groups match either A or An, the RX_OH_sequence_i(5) is set to 1 and is otherwise set to 0.

If the optional Clause 45 MDIO is implemented, the PMA receive process maps the RX_OH_pattern and RX_OH_sequence_i variables to the registers and bits defined in 94.2.10. The default values for each of the control variables are summarized in Table 94–3.

Table 94–3—Default overhead control values

Parameter	Values (binary)
RX_OH_pattern(7:0)	01100110

94.2.4 Skew constraints

Skew considerations for the 100GBASE-KP4 PMA, PMD, and AN are specified in 94.3.4.

94.2.5 Delay constraints

Delay considerations for the 100GBASE-KP4 PMA, PMD, AN, and medium are specified in 94.3.3.

94.2.6 Link status

The PMA shall provide link status information to the PMA client using the PMA:IS_SIGNAL.indication primitive (see 94.2.1.3). The PMA continuously monitors the link status reported by the PMD from the PMD:IS_SIGNAL.indication primitive, and uses this as input to Signal Indication Logic (SIL) to determine the link status to report to the PMA client. Other inputs to the SIL may include status of clock and data recovery on the lanes from the PMD and frame synchronization.

94.2.7 PMA local loopback mode

PMA local loopback shall be provided. This function involves looping back each input lane from the PMA service interface to the corresponding output lane on the PMA service interface. Each received instance of the PMA:IS_UNITDATA_i.request(tx_bit,start) primitive is looped back in the direction of the PMA client using the PMA:IS_UNITDATA_i.indication(rx_bit,start) primitive.

During local loopback, the PMA performs normal framing and precoding onto the lanes in the Tx direction toward the PMD service interface.

Ability to perform this function is indicated by the Local_loopback_ability status variable. The Local_loopback_ability status variable is always set to 1. If a Clause 45 MDIO is implemented, this variable is accessible through bit 1.8.0 (45.2.1.7.15). A device is placed in local loopback mode when the

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Local_loopback_enable control variable is set to one, and removed from local loopback mode when this variable is set to zero. If a Clause 45 MDIO is implemented, this variable is accessible through PMA/PMD control 1 register (bit 1.0.0, see 45.2.1.1.5).

94.2.8 PMA remote loopback mode (optional)

PMA remote loopback mode is optional. If implemented, it shall be as described in this subclause.

Remote loopback, if provided, should be implemented close enough to the PMD to maintain the bit sequence on each individual PMD lane. When remote loopback is enabled, each bit received over a lane of the service interface below the PMA via PMD:IS_UNITDATA_*i*.indication is looped back to the corresponding output lane toward the PMD via PMD:IS_UNITDATA_*i*.request.

During remote loopback, the PMA performs normal bit processing operation in the Rx direction towards the PMA client.

The ability to perform this function is indicated by the Remote_loopback_ability status variable. If a Clause 45 MDIO is implemented, this variable is accessible through bit 1.13.15 (Clause 45.2.1.2.3). A device is placed in remote loopback mode when the Remote_loopback_enable control variable is set to one, and removed from remote loopback mode when this variable is set to zero. If a Clause 45 MDIO is implemented, this variable is accessible through PMA/PMD Control register 1 (bit 1.0.1, see Clause 45.2.1.1.4).

94.2.9 PMA test patterns

94.2.9.1 JP03A test pattern

A 100GBASE-KP4 PMA shall include a JP03A test pattern generator as specified in this subclause.

The JP03A test pattern is generated prior to PAM4 encoding. When the JP03A test pattern is enabled, it replaces the signal from the precoder. The JP03A test pattern is a repeating {0,3} sequence.

The JP03A test pattern is enabled by the test_pattern_enable and JP03A_enable control variables. If the optional Clause 45 MDIO is implemented, the control variables map to the registers and bits defined in 94.2.10.

94.2.9.2 JP03B test pattern

A 100GBASE-KP4 PMA shall include a JP03B test pattern generator as specified in this subclause.

The JP03B test pattern is generated prior to PAM4 encoding. When the JP03B test pattern is enabled, it replaces the signal from the precoder. The JP03B test pattern is a repeating sequence of {0,3} repeated 15 times followed by {3,0} repeated 16 times. The entire 62-symbol pattern is shown in Equation (94–1).

$$03030303030303030303030303033030303030303030303030303030303030 \quad (94\text{–}1)$$

The JP03B test pattern is enabled by the test_pattern_enable and JP03B_enable control variables. If the optional Clause 45 MDIO is implemented, the control variables map to the registers and bits defined in 94.2.10.

94.2.9.3 Quaternary PRBS13 test pattern

A 100GBASE-KP4 PMA shall include a quaternary PRBS13 (QPRBS13) pattern generator as specified in this subclause.

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The QPRBS13 test pattern is a repeating 15548-symbol (338 training frame words) sequence equivalent to the training pattern specified in 94.3.10.8.

The PRBS13 pattern generator is re-initialized for each repetition of QPRBS13 with the same seeds specified in Table 94–11.

The QPRBS13 test pattern is enabled by the test_pattern_enable and QPRBS13_enable control variables. If the optional Clause 45 MDIO is implemented, the control variables map to the registers and bits defined in 94.2.10.

94.2.9.4 Transmitter linearity test pattern

A 100GBASE-KP4 PMA shall include a transmitter linearity test pattern generator as specified in this subclause.

The transmitter linearity test pattern is a repeating 160-symbol pattern with a sequence of 10 symbol values each 16 UI in duration. The 10 values correspond to the set of PAM4 symbols shown in Equation (94–2).

$$\{-1,-1/3,+1/3,+1,-1,+1,-1,+1,+1/3,-1/3\} \quad (94–2)$$

The transmitter linearity test pattern is enabled by the test_pattern_enable and TX_linearity_enable control variables. If the optional Clause 45 MDIO is implemented, the control variables map to the registers and bits defined in 94.2.10.

94.2.10 PMA MDIO function mapping

Clause 45 specifies the optional MDIO capability that describes several registers that provide control and status information for and about the PMA. 45.2.1 describes the Management Data Input/Output (MDIO) Manageable Device (MMD) addresses. If MDIO is implemented, it shall map MDIO control bits to PMA control variables as shown in Table 94–4, and MDIO status bits to PMA status variables as shown in Table 94–5.

Table 94–4—100GBASE-KP4 MDIO/PMA control variable mapping

MDIO control variable	PMA/PMD register name	Register/bit number	PMA control variable
PMA local loopback	PMA/PMD control 1	1.0.0	Local_loopback_enable
PMA remote loopback	PMA/PMD status 2	1.0.1	Remote_loopback_enable
PMA Tx generator enable	PRBS pattern testing control	1.1501.3	test_pattern_enable
JP03A pattern enable	PRBS pattern testing control	1.1501.8	JP03A_enable
JP03B pattern enable	PRBS pattern testing control	1.1501.9	JP03B_enable
QPRBS13 pattern enable	PRBS pattern testing control	1.1501.10	QPRBS13_enable
TX linearity pattern enable	PRBS pattern testing control	1.1501.11	TX_linearity_enable
PMA transmit overhead pattern	PMA overhead control 1	1.162.7:0	TX_OH_pattern
PMA transmit overhead sequence 0	PMA overhead control 1	1.162.12:8	TX_OH_sequence_0
PMA transmit overhead sequence 1	PMA overhead control 2	1.163.4:0	TX_OH_sequence_1

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Table 94–4—100GBASE-KP4 MDIO/PMA control variable mapping *(continued)*

MDIO control variable	PMA/PMD register name	Register/bit number	PMA control variable
PMA transmit overhead sequence 2	PMA overhead control 2	1.163.9:5	TX_OH_sequence_2
PMA transmit overhead sequence 3	PMA overhead control 2	1.163.14:10	TX_OH_sequence_3
PMA receive overhead pattern	PMA overhead control 3	1.164.7:0	RX_OH_pattern

Table 94–5—100GBASE-KP4 MDIO/PMA status variable mapping

MDIO status variable	PMA/PMD register name	Register/bit number	PMA status variable
PMA local loopback ability	PMA/PMD status 2	1.8.0	Local_loopback_ability
PMA remote loopback ability	40G/100G PMA/PMD extended ability	1.13.15	Remote_loopback_ability
PMA receive overhead sequence 0	PMA overhead status 1	1.165.5:0	RX_OH_sequence_0
PMA receive overhead sequence 1	PMA overhead status 1	1.165.11:6	RX_OH_sequence_1
PMA receive overhead sequence 2	PMA overhead status 2	1.166.5:0	RX_OH_sequence_2
PMA receive overhead sequence 3	PMA overhead status 2	1.166.11:6	RX_OH_sequence_3

94.3 Physical Medium Dependent (PMD) Sublayer

94.3.1 Physical Medium Dependent (PMD) service interface

This subclause specifies the services provided by the 100GBASE-KP4 PMD. The service interface for this PMD is described in an abstract manner and does not imply any particular implementation. The PMD service interface supports the exchange of encoded data. The PMD translates the encoded data to and from signals suitable for the medium.

The PMD service interface is based on the inter-sublayer service interface defined in 80.3. The PMD service interface primitives are summarized as follows:

PMD:IS_UNITDATA_*i*.request
PMD:IS_UNITDATA_*i*.indication
PMD:IS_SIGNAL.indication

If the optional EEE deep sleep capability is supported, then the PMD service interface includes two additional primitives as follows:

PMD:IS_TX_MODE.request
PMD:IS_RX_MODE.request

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94.3.1.1 PMD:IS_UNITDATA_i.request

The PMD:IS_UNITDATA_*i*.request (where *i*=0 to 3) primitive is used to define the transfer of four streams of data units from the PMA to the PMD.

94.3.1.1.1 Semantics of the service primitive

PMD:IS_UNITDATA_0.request(tx_symbol)
PMD:IS_UNITDATA_1.request(tx_symbol)
PMD:IS_UNITDATA_2.request(tx_symbol)
PMD:IS_UNITDATA_3.request(tx_symbol)

The data conveyed by PMD:IS_UNITDATA_i.request consists of four parallel continuous streams of encoded symbols, tx_symbol, one stream for each lane. Each of the tx_symbol parameters can take one of four values: –1, –1/3, +1/3, or +1.

94.3.1.1.2 When generated

The PMA continuously sends four parallel symbol streams PMD:IS_UNITDATA_*i*.request(tx_symbol) to the PMD, each at a nominal signaling rate of 13.59375 GBd.

94.3.1.1.3 Effect of receipt

Upon receiving each instance of PMD:IS_UNITDATA_*i*.request, the tx_symbol parameter is passed to the PMD transmit process corresponding to each stream.

94.3.1.2 PMD:IS_UNITDATA_i.indication

The PMD:IS_UNITDATA_*i*.indication (where *i*=0 to 3) primitive is used to define the transfer of four streams of data units from the PMD to the PMA.

94.3.1.2.1 Semantics of the service primitive

PMD:IS_UNITDATA_0.indication(rx_symbol)
PMD:IS_UNITDATA_1.indication(rx_symbol)
PMD:IS_UNITDATA_2.indication(rx_symbol)
PMD:IS_UNITDATA_3.indication(rx_symbol)

The data conveyed by PMD:IS_UNITDATA_0.indication to PMD:IS_UNITDATA_3.indication consists of four parallel continuous streams of encoded symbols, one stream for each lane. Each of the rx_symbol parameters can take one of four values: –1, –1/3, +1/3, or +1.

94.3.1.2.2 When generated

The PMD continuously sends four parallel encoded symbol streams PMD:IS_UNITDATA_*i*.indication(rx_symbol) to the PMD client, each at a nominal signaling rate of 13.59375 GBd.

94.3.1.2.3 Effect of receipt

The effect of receipt of this primitive is undefined by the PMD.

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94.3.1.3 PMD:IS_SIGNAL.indication

The PMD:IS_SIGNAL.indication primitive is generated by the PMD to the PMA to indicate the status of the PMD receive process. This primitive is generated by the PMD receive process to propagate the detection of severe error conditions (e.g., loss of synchronization) to the PMA.

94.3.1.3.1 Semantics of the service primitive

PMD:IS_SIGNAL.indication(SIGNAL_OK).

The SIGNAL_OK parameter corresponds to the variable Global_PMD_signal_detect as defined in 94.3.6.4. When Global_PMD_signal_detect is one, SIGNAL_OK shall be assigned the value OK. When Global_PMD_signal_detect is zero, SIGNAL_OK shall be assigned the value FAIL. When SIGNAL_DETECT = FAIL, the PMD:IS_UNITDATA_*i*.indication parameters are undefined.

94.3.1.3.2 When generated

The PMD generates the PMD:IS_SIGNAL.indication primitive to the PMD client whenever there is change in the value of the Global_PMD_signal_detect parameter.

94.3.1.3.3 Effect of receipt

The effect of receipt of this primitive is undefined by the PMD.

94.3.2 PCS requirements for Auto-Negotiation (AN) service interface

The PCS associated with this PMD is required to support the AN service interface primitive AN_LINK.indication defined in 73.9. (See 82.6.)

The 100GBASE-KP4 PHY may be extended using CAUI-n as a physical instantiation of the inter-sublayer service interface between devices. If CAUI-n is instantiated, the AN_LINK(link_status).indication is relayed from the device with the PCS sublayer to the device with the AN sublayer by means at the discretion of the implementer. As examples, the implementer may employ use of pervasive management or employ a dedicated electrical signal to relay the state of link_status as indicated by the PCS sublayer on one device to the AN sublayer on the other device.

94.3.3 Delay constraints

The sum of the transmit and the receive delays contributed by the 100GBASE-KP4 PMA, PMD, AN, and the medium in one direction shall be no more than 8192 bit times (16 pause_quanta or 81.92 ns). It is assumed that the one way delay through the medium is no more than 800 bit times (8 ns).

A description of overall system delay constraints and the definitions for bit times and pause_quanta can be found in 80.4 and its references.

94.3.4 Skew constraints

The Skew (relative delay) between the lanes must be kept within limits so that the information on the lanes can be reassembled by the RS-FEC sublayer. Skew and Skew Variation are defined in 80.5 and specified at the points SP1 to SP6 shown in Figure 80–8.

If the PMD service interface is physically instantiated so that the Skew at SP2 can be measured, then the Skew at SP2 is limited to 43 ns and the Skew Variation at SP2 is limited to 0.4 ns.

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The Skew at SP3 (the transmitter MDI) shall be less than 54 ns and the Skew Variation at SP3 shall be less than 0.6 ns.

The Skew at SP4 (the receiver MDI) shall be less than 134 ns and the Skew Variation at SP4 shall be less than 3.4 ns.

If the PMD service interface is physically instantiated so that the Skew at SP5 can be measured, then the Skew at SP5 shall be less than 145 ns and the Skew Variation at SP5 shall be less than 3.6 ns.

For more information on Skew and Skew Variation see 80.5.

94.3.5 PMD MDIO function mapping

The optional MDIO capability described in Clause 45 defines several registers that provide control and status information for and about the PMD. If MDIO is implemented, it shall map MDIO control bits to PMD control variables as shown in Table 94–6, and MDIO status bits to PMD status variables as shown in Table 94–7.

Table 94–6—100GBASE-KP4 MDIO/PMD control variable mapping

MDIO control variable	PMA/PMD register name	Register/bit number	PMD control variable
Reset	PMA/PMD control 1	1.0.15	PMD_reset
Global PMD transmit disable	PMD transmit disable	1.9.0	Global_PMD_transmit_disable
PMD transmit disable 3 to PMD transmit disable 0	PMD transmit disable	1.9.4 to 1.9.1	PMD_transmit_disable_3 to PMD_transmit_disable_0
Restart training	BASE-R PMD control	1.150.0	mr_restart_training
Training enable	BASE-R PMD control	1.150.1	mr_training_enable

Table 94–7—100GBASE-KP4 MDIO/PMD status variable mapping

MDIO status variable	PMA/PMD register name	Register/bit number	PMD status variable
Fault	PMA/PMD status 1	1.1.7	PMD_fault
Transmit fault	PMA/PMD status 2	1.8.11	PMD_transmit_fault
Receive fault	PMA/PMD status 2	1.8.10	PMD_receive_fault
Global PMD receive signal detect	PMD receive signal detect	1.10.0	Global_PMD_signal_detect
PMD receive signal detect 3 to PMD receive signal detect 0	PMD receive signal detect	1.10.4 to 1.10.1	PMD_signal_detect_3 to PMD_signal_detect_0
100GBASE-KP4 deep sleep	EEE capability	1.16.9	—
Receiver status 3	BASE-R PMD status	1.151.12	rx_trained_3
Frame lock 3	BASE-R PMD status	1.151.13	frame_lock_3

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Table 94–7—100GBASE-KP4 MDIO/PMD status variable mapping *(continued)*

MDIO status variable	PMA/PMD register name	Register/bit number	PMD status variable
Start-up protocol status 3	BASE-R PMD status	1.151.14	training_3
Training failure 3	BASE-R PMD status	1.151.15	training_failure_3
Receiver status 2	BASE-R PMD status	1.151.8	rx_trained_2
Frame lock 2	BASE-R PMD status	1.151.9	frame_lock_2
Start-up protocol status 2	BASE-R PMD status	1.151.10	training_2
Training failure 2	BASE-R PMD status	1.151.11	training_failure_2
Receiver status 1	BASE-R PMD status	1.151.4	rx_trained_1
Frame lock 1	BASE-R PMD status	1.151.5	frame_lock_1
Start-up protocol status 1	BASE-R PMD status	1.151.6	training_1
Training failure 1	BASE-R PMD status	1.151.7	training_failure_1
Receiver status 0	BASE-R PMD status	1.151.0	rx_trained_0
Frame lock 0	BASE-R PMD status	1.151.1	frame_lock_0
Start-up protocol status 0	BASE-R PMD status	1.151.2	training_0
Training failure 0	BASE-R PMD status	1.151.3	training_failure_0

94.3.6 PMD functional specifications

94.3.6.1 Link block diagram

One direction for one lane of a 100GBASE-KP4 link is shown in Figure 94–4.

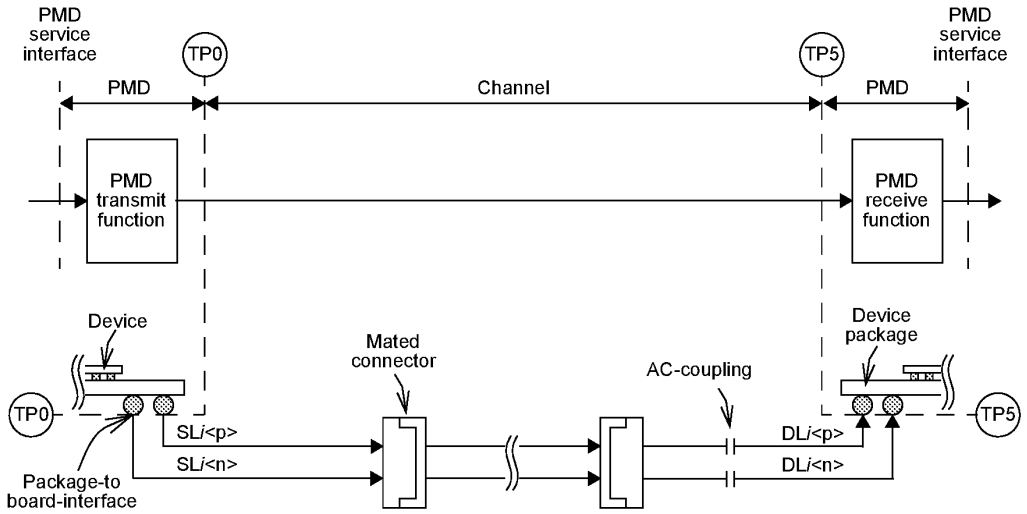


Figure 94–4—100GBASE-KP4 link (one direction for one lane is illustrated)

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94.3.6.2 PMD Transmit function

The PMD transmit function shall convert the four encoded symbol streams requested by the PMD service interface messages PMD:IS_UNITDATA_i.request (i=0 to 3) into four separate electrical signals. The four electrical signals shall then be delivered to the MDI, all according to the transmit electrical specifications in 94.3.12. A positive differential output voltage (SL*i*<p> minus SL*i*<n>) shall correspond to a positive tx_symbol value.

If the optional EEE deep sleep capability is supported, the PMD transmit function shall transmit a periodic sequence, where each period of the sequence is an ALERT frame (see 94.3.11.1) when tx_mode is set to ALERT. Regardless of tx_mode, the transmit equalizer coefficients shall be set to the values determined via the start-up protocol (see 94.3.10).

94.3.6.3 PMD Receive function

The PMD receive function shall convert the four electrical signals from the MDI into four encoded symbol streams for delivery to the PMD service interface using the messages PMD:IS_UNITDATA_i.indication (i=0 to 3). A positive differential input voltage of (DL*i*<p> minus DL*i*<n>) shall correspond to a positive rx_symbol value.

94.3.6.4 Global PMD signal detect function

The variable Global_PMD_signal_detect is the logical AND of the values of PMD_signal_detect_i for i=0 to 3.

When the MDIO is implemented, this function maps the variable Global_PMD_signal_detect to the register and bit specified in 94.3.5.

94.3.6.5 PMD lane-by-lane signal detect function

The PMD lane-by-lane signal detect function is used by the 100GBASE-KP4 PMD to indicate the successful completion of the start-up protocol by the PMD control function (see 94.3.10). PMD_signal_detect_i (where i represents the lane number in the range 0 to 3) is set to zero when the value of the variable signal_detect is set to false by the Training state diagram for lane i (see Figure 72–5). PMD_signal_detect_i is set to one when the value of signal_detect for lane i is set to true.

If training is disabled by the management variable mr_training_enable (see 94.3.5), PMD_signal_detect_i shall be set to one for i=0 to 3.

If the optional EEE deep sleep capability is supported, the following requirements apply. The value of PMD_signal_detect_i (for i=0 to 3) is set to zero when rx_mode is first set to QUIET. While rx_mode is set to QUIET, PMD_signal_detect_*i* shall be set to one within 500 ns of the application of the ALERT pattern defined in 94.3.6.2 and meeting the EEE transmit-enabled amplitude requirement of 94.3.12.3. While rx_mode is set to QUIET, PMD_signal_detect_*i* shall not be set to one when the output of the transmitter on the same lane meets the EEE transmit-disabled amplitude requirement of 94.3.12.3.

When the MDIO is implemented, this function maps the variables to registers and bits as defined in 94.3.5.

94.3.6.6 Global PMD transmit disable function

The Global PMD transmit disable function is mandatory if EEE deep sleep capability is supported and is otherwise optional. When implemented, it allows all of the transmitters to be disabled with a single variable.

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a) When Global_PMD_transmit_disable variable is set to one, this function shall turn off all of the transmitters such that each transmitter drives a constant level (i.e., no transitions) and does not exceed the maximum differential peak-to-peak output voltage in Table 94–13.

b) If a PMD fault (94.3.7) is detected, then the PMD may set Global_PMD_transmit_disable to one.

c) Loopback, as defined in 94.3.6.8, shall not be affected by Global_PMD_transmit_disable.

d) The following additional requirements apply when the optional EEE deep sleep capability is supported. The Global PMD transmit disable function shall turn off all of the transmitters as specified in 94.3.12.3 when tx_mode transitions to QUIET from any other value. The Global PMD transmit disable function shall turn on all of the transmitters as specified in 94.3.12.3 when tx_mode transitions from QUIET to any other value.

94.3.6.7 PMD lane-by-lane transmit disable function

The PMD lane-by-lane transmit disable function is optional and allows the electrical transmitter in each lane to be selectively disabled. When this function is supported, it shall meet the following requirements:

a) When a PMD_transmit_disable_*i* variable (where i represents the lane number in the range 0 to 3) is set to one, this function shall turn off the transmitter associated with that variable such that it drives a constant level (i.e., no transitions) and does not exceed the maximum differential peak-to-peak output voltage specified in Table 94–13.

b) If a PMD_fault (94.3.7) is detected, then the PMD may set each PMD_transmit_disable_*i* to one, turning off the electrical transmitter in each lane.

c) Loopback, as defined in 94.3.6.8, shall not be affected by PMD_transmit_disable_*i*.

94.3.6.8 Loopback mode

Local loopback mode is provided by the PMA (94.2.7). Loopback shall not affect the state of the transmitter, which continues to send data unless disabled (94.3.6.7).

NOTE—Placing a network port into loopback mode can be disruptive to a network.

94.3.7 PMD fault function

PMD_fault is the logical OR of PMD_receive_fault, PMD_transmit_fault, and any other implementation specific fault.

If the MDIO is implemented, PMD_fault shall be mapped to the fault bit as specified in 45.2.1.2.3.

94.3.8 PMD transmit fault function

The PMD transmit fault function is optional. The faults detected by this function are implementation specific, but the assertion of Global_PMD_transmit_disable is not considered a transmit fault. A fault is indicated by setting the variable PMD_transmit_fault to one.

If PMD_transmit_fault is asserted, then Global_PMD_transmit_disable should also be asserted.

If the MDIO interface is implemented, then this function shall be mapped to the Transmit fault bit as specified in 45.2.1.7.4.

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94.3.9 PMD receive fault function

The PMD receive fault function is optional. The faults detected by this function are implementation specific. A fault is indicated by setting the variable PMD_receive_fault to one.

If the MDIO interface is implemented, then PMD_receive_fault shall contribute to the Receive fault bit as specified in 45.2.1.7.5.

94.3.10 PMD control function

94.3.10.1 Overview

The PMD control function generates the control actions required to bring the PMD from initialization to a mode in which data may be exchanged with the link partner.

The PMD control function is based upon the 10GBASE-KR start-up protocol. This protocol facilitates timing recovery and equalization while also providing a mechanism through which the receiver can tune the transmit equalizer to optimize performance over the backplane interconnect. The protocol supports these mechanisms through the continuous exchange of fixed-length training frames.

Each lane of the 100GBASE-KP4 PMD shall have an independent control function as defined in this subclause.

The variables rx_trained_*i*, frame_lock_*i*, training_*i*, and training_failure_*i* (where *i* goes from 0 to 3) report status for each lane and are equivalent to rx_trained, frame_lock, training, and training_failure as defined in 72.6.10.3.1. If the MDIO interface is implemented, then this function shall map these variables to the appropriate bits in the BASE-R PMD status register (Register 1.151) as specified in 45.2.1.81.

94.3.10.2 Training frame structure

The training frame is a fixed length structure that is sent continuously during training. The training frame, shown in Figure 94–5, is 348 training frame words (94.3.10.3) in length and contains a frame marker, a control channel, and training pattern. The frame marker delimits the beginning of a training frame. The control channel provides a means for the each receiver to control the taps on the link partner transmitter and communicate status. The training pattern provides content rich pattern for receiver convergence.

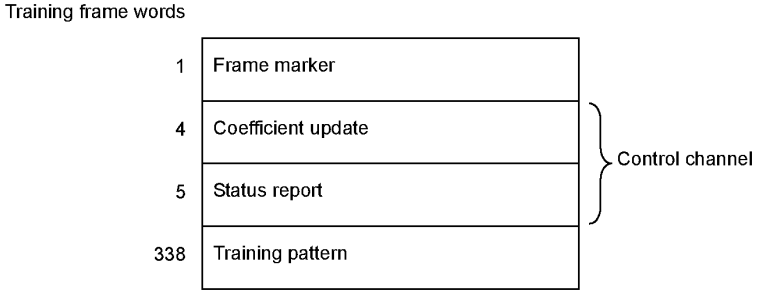


Figure 94–5—Training frame structure

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94.3.10.3 Training frame words

Each training frame is composed of a series of 348 training frame words. Each training frame word is 46 symbols in length, equivalent in size to a termination block described in 94.2.2.4.

94.3.10.4 Frame marker

Each training frame shall be delimited by a frame marker as described in this subclause. The frame marker is a training frame word composed of a 46-symbol pattern of 23 +1 symbols followed by 23 –1 symbols. This pattern does not appear in the control channel or the training pattern and therefore serves as a unique indicator of the start of a training frame.

94.3.10.5 Control channel encoding

94.3.10.5.1 Differential Manchester encoding

The control channel shall be transmitted using differential Manchester encoding (DME). DME guarantees transition density and DC balance while the reduced rate of transmission facilitates reception over non-optimally equalized channels.

DME cells shall be encoded using the following rules:

a) Each DME cell represents one bit of information.
b) The upper value is represented by a series of PAM4 +1 symbols.
c) The lower value is represented by a series of PAM4 –1 symbols.
d) A data transition occurs at each cell boundary.
e) A mid-cell data transition is used to signal a logical one.
f) The absence of a mid-cell data transition is used to signal a logical zero.

If a coding violation is detected within the bounds of the control channel in a given training frame, the contents of the control channel for that frame shall be ignored.

94.3.10.5.2 Control channel structure

The control channel shall be constructed of a series of DME cells as described in this subclause.

The control channel is composed of a series of 9 training frame words. Each training frame word is composed of four 10-symbol control channel DME cells and a 6-symbol control overhead DME cell.

The control overhead cell is always transmitted as a one following the DME rules. In other words, the control overhead cell is transmitted as either three +1 symbols followed by three –1 symbols or vice versa depending on the previously transmitted control channel cell.

The coefficient update field is transmitted in the first 16 control channel DME cells. The status report field is transmitted in the next 24 control channel DME cells. The structure of the frame marker and control channel are shown in Table 94–8.

94.3.10.6 Coefficient update field

The coefficient update field carries correction information from the local receiver to the link partner transmit equalizer. The field consists of preset controls, initialization controls, coefficient updates for three transmit equalizer taps, and parity. The coefficient update field is mapped into the first 16 control channel DME

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Table 94–8—Frame marker and control channel structure

Training frame word	Symbols 1:10	Symbols 11:20	Symbols 21:30	Symbols 31:40	Symbols 41:46	Training frame fields
1	cell 15	cell 14	cell 13	cell 12	overhead	coefficient update
2	cell 11	cell 10	cell 9	cell 8	overhead	
3	cell 7	cell 6	cell 5	cell 4	overhead	
4	cell 3	cell 2	cell 1	cell 0	overhead	
5	cell 19	cell 18	cell 17	cell 16	overhead	status report
6	cell 15	cell 14	cell 13	cell 12	overhead	
7	cell 11	cell 10	cell 9	cell 8	overhead	
8	cell 7	cell 6	cell 5	cell 4	overhead	
9	cell 3	cell 2	cell 1	cell 0	overhead	

The format of the coefficient update field shall be as shown in Table 94–9. Cell 15 of the coefficient update field shall be transmitted first. The preset, initialize, and coefficient update fields are set by the receiver adaptation process. The algorithm employed by the receiver adaptation process is beyond the scope of this standard.

Table 94–9—Coefficient update field

Cell(s)	Name	Description
15:14	Reserved	Transmitted as 0, ignored on reception.
13	Preset	1 = Preset coefficients 0 = Normal operation
12	Initialize	1 = Initialize coefficients 0 = Normal operation
11:7	Reserved	Transmitted as 0, ignored on reception.
6	Parity	Even parity of all other coefficient update cells.
5:4	Coefficient (+1) update	5 4 1 1 = reserved 0 1 = increment 1 0 = decrement 0 0 = hold
3:2	Coefficient (0) update	3 2 1 1 = reserved 0 1 = increment 1 0 = decrement 0 0 = hold
1:0	Coefficient (–1) update	1 0 1 1 = reserved 0 1 = increment 1 0 = decrement 0 0 = hold

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94.3.10.6.1 Preset

The behavior in response to the preset field shall be as specified in 72.6.10.2.3.1.

94.3.10.6.2 Initialize

The behavior in response to the initialize field shall be as specified in 72.6.10.2.3.2, except that the conditions for the INITIALIZE state are specified in 94.3.12.5.4 instead of 72.6.10.4.2.

94.3.10.6.3 Parity

The parity bit shall be set so that all bits in the coefficient update field including the parity bit exhibit even parity. The parity bit protects against acceptance of errored control messages and preserves DC balance. If a parity violation is detected within a received coefficient update field, that field shall not be used to update the transmitter coefficients.

94.3.10.6.4 Coefficient (*k*) update

The coefficient update fields shall be encoded as described in this subclause.

Each coefficient, identified by the index k, is assigned a 2-bit field describing a requested update, where $k \in \{-1, 0, 1\}$ denoting the pre-cursor, main, and post-cursor taps, respectively. The encoding of the coefficient update fields are as shown in Table 94–9.

Three request encodings are defined: increment, decrement, and hold. The default state of each tap is hold, which corresponds to no change in the coefficient. The increment or decrement encodings are transmitted to request that the corresponding coefficient be increased or decreased. The amount of change implemented by the transmitter in response to the coefficient update request meets the requirements of 94.3.12.5.5. An increment or decrement request is transmitted continuously until the update status (94.3.10.7.4) for that tap indicates updated, maximum, or minimum. At that point, the outgoing requests for that tap may be set to hold. The hold setting must be maintained until the incoming status message for that tap reverts to not_updated. A new request to increment or decrement a tap may be sent only when the incoming status message for that tap is not_updated.

Coefficient increment and decrement update requests must not be sent in combination with initialize or preset.

94.3.10.7 Status report field

The status report field is used to signal state information from the local PMD to the link partner. The format of the status report field of training frames shall be as shown in Table 94–10. Cell 19 of the status report field shall be transmitted first.

Table 94–10—Status report field for training and alert frames

Cell(s)	Name	Description
19	Parity	Set to achieve even parity for status report field.
18	Mode	0: Training 1: EEE
17:16	Frame countdown	Number of frames remaining before transition to data mode.

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Table 94–10—Status report field for training and alert frames *(continued)*

Cell(s)	Name	Description
15:13	PMA alignment offset	Relative location of the next alert frame within the PMA frame (set to zero for training frames).
12:7	Reserved	Transmitted as zeros.
6	Receiver ready	1 = The local receiver has determined that training is complete and is prepared to receive data. 0 = The local receiver is requesting that training continue.
5:4	Coefficient (+1) status	5 4 1 1 = maximum 1 0 = minimum 0 1 = updated 0 0 = not_updated (and for EEE alert frames)
3:2	Coefficient (0) status	3 2 1 1 = maximum 1 0 = minimum 0 1 = updated 0 0 = not_updated (and for EEE alert frames)
1:0	Coefficient (–1) status	1 0 1 1 = maximum 1 0 = minimum 0 1 = updated 0 0 = not_updated (and for EEE alert frames)

94.3.10.7.1 Parity

The parity cell shall be set so that all bits in the status report field including the parity bit exhibit even parity. The parity bit protects against acceptance of errored status messages and preserves DC balance. If a parity violation is detected within a received status field, that field shall not be used to determine the link partner status.

94.3.10.7.2 Training frame countdown

The training frame countdown cell shall signal the transition from training to data mode as described in this subclause. When training begins, countdown is set to the value 3 and remains so until all receivers have completed training. When the received status report receiver ready is 1 in all four received lanes and the transmitted status report receiver ready is 1 in all four transmitted lanes, the transmitter on each transmitted lane decrements the countdown in three successive frames. The countdown values are equal in all four lanes. In other words, in the last three training frames countdown contains 2, 1, and 0, respectively. Immediately after the last training frame word of the last training frame is sent, transmission of the PMA frame begins starting with the termination block containing the PMA overhead (see 94.3.10.9).

94.3.10.7.3 Receiver ready

The receiver ready bit shall signal the local receiver state to the link partner as described in this subclause. When training begins the receiver ready bit is deasserted and remains so until the receiver has concluded training. The receiver ready bit is asserted to indicate that the local receiver has concluded training and is prepared to receive data. The encoding of the receiver ready bit is as shown in Table 94–10.

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94.3.10.7.4 Coefficient (*k*) status

The behavior of the coefficient (*k*) status fields shall be as specified in 72.6.10.2.4.5.

94.3.10.7.5 Coefficient update process

The coefficient update process shall behave as specified in 72.6.10.2.5.

In addition, the period from receiving a new request to responding to that request shall be less than 2 ms, except during the first 50 ms following the beginning of the start-up protocol. The beginning of the start-up protocol is defined to be entry into the AN_GOOD_CHECK state in Figure 73–10. The start of the period is the frame marker of the training frame with the new request and the end of the period is the frame marker of the training frame with the corresponding response. A new request occurs when the coefficient update field is different from the coefficient field in the preceding frame. The response occurs when the coefficient status report field is updated to indicate that the corresponding action is complete.

94.3.10.8 Training pattern

The training pattern shall be encoded as specified in this subclause.

The training pattern is mapped into a series of 338 training frame words. Each training frame words is encoded as a PMA signal as specified in 94.2.2 with the exception that the input is from a PRBS13 generator rather than from the PMA service interface and no PMA overhead (94.2.2.2) is inserted.

For each training frame, the PRBS13 generator is used to produce 31096 bits. Three full cycles of 8191 bits and one truncated cycle of 6523 bits are concatenated to form the 31096 bit sequence, R(1:31096). Bits in the first and third cycle, R(1:8191) and R(16383:24573), are not inverted and bits in the second and fourth cycles, R(8192:16382) and R(24574:31096), are inverted.

The PRBS13 pattern generator produces the same result as the implementation shown in Figure 94–6, which implements the generator polynomial shown in Equation (94–3). The PRBS13 pattern generator is initialized for each frame using a unique seed for each lane. The 13-bit seed and the initial 16 bits for each lane are annotated in Table 94–11.

$$G(x) = 1 + x + x^2 + x^{12} + x^{13} \tag{94–3}$$

The PRBS13 pattern is mapped into the 92 bits of each training frame word. The first 2 bits of each training frame word form the termination bits (94.2.2.4) and each training frame word in the training pattern is equivalent to a termination block (94.2.2.4). The resulting termination blocks are gray-mapped (94.2.2.5), precoded (94.2.2.6), and mapped to PAM4 levels (94.2.2.7).

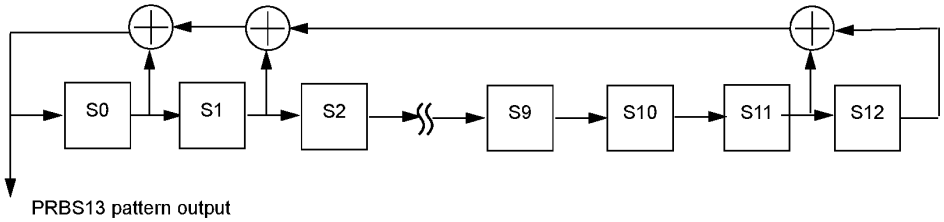


Figure 94–6—PRBS13 pattern generator

The outputs of PRBS13 generator, gray mapper, and precoder for the first two training frame words are provided in Table 94–12.

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Table 94–11—PRBS13 seeds and initial output

PMD Lane	Seed bits (leftmost bit in S0, rightmost in S12)	Initial 16 bits (in order of transmission)
0	0000010101011	0100100110110011
1	0011101000001	1101111101010100
2	1001000101100	1100101111000011
3	0100010000010	0110111101000111

Table 94–12—Training pattern initial sequences

PMD Lane	Output of	Contents of first (top) and second (bottom) training frame words transmitted left to right
0	PRBS13	0100100110110011110001010101100001001001110111100111010000011 1010011011101001110011001010111 0001111111010111011011111101000101101111101001111011001010110 0111001001110000111100001101011
	Gray code	1031320220111130103121231210012102121023131112 0122211213222101132233123203320231023012301332
	Precoder	1301200200101031003201123322233220110021032320 0111101103333223211121021130331123112233001211
1	PRBS13	1101111101010100000010010011011001111000101010110000100100111 0111100111010000011101001101110 1001110011001010111000111111101011101101111110100010110111110 1001111011001010110011100100111
	Gray code	2122111000310213123033320031023220233002331323 3120203323022233232122330321221022131113120312
	Precoder	2333232222100230112212113123112022030002123021 3200221203111121120111213023332202301012331233
2	PRBS13	1100101111000011111011101110110011001100111000111000110000110 0001110111000001100110000001110 0011011000011000101011000110010011101010100011001001000011100 1111011101010110011001001010101
	Gray code	2032200223232320202023023020020023230020200023 0213013033201310233330203100231232333202031111
	Precoder	2211131112033022002203112200022203300022000021 0230012212001231121213312313301120303311301010
3	PRBS13	0110111101000111101111101011001101111110001111011010111011110 0100001011000101100101011111000 1001011010111100101001011000100111110000101011010110010011111 1000101011011101001000101111100
	Gray code	1322101232233202122302213323220301130320332230 3113322033113031220033211310222011132331011220
	Precoder	1202310211121133202133321203331223213022120213 3230333121012210200030232100202232302123101113

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94.3.10.9 Transition from training to data

The transmitted signal shall transition from the training signal to normal data as described in this subclause.

The transition from the training signal to normal data occurs when the training countdown is complete, as indicated by the training frame countdown being equal to 0 (94.3.10.7.2). Immediately after the last bit of the last training frame, transmission of the first PMA frame (94.2.2.4) begins with the termination block containing the overhead, T(i,1,1:92). The PRBS13 generator used during training to generate the training pattern is used to generate the termination bits in data mode. The state of the training PRBS13 generator is retained and 92 new bits are generated without reseeding or inverting. Termination bits are assigned and the PRBS13 generator continues to operate as specified in 94.2.2.4. The transition from training to data mode and mapping of the PRBS13 to training frame and termination bits is depicted in Figure 94–7.

94.3.10.10 Frame lock state diagram

The 10GBASE-KP4 PMD shall implement the frame lock state diagram as depicted in Figure 72–4 including compliance with the associated state variables, timers, counters, and functions specified in 72.6.10.3. The frame lock state diagram determines when the PMD control function has detected the frame boundaries in the received data stream.

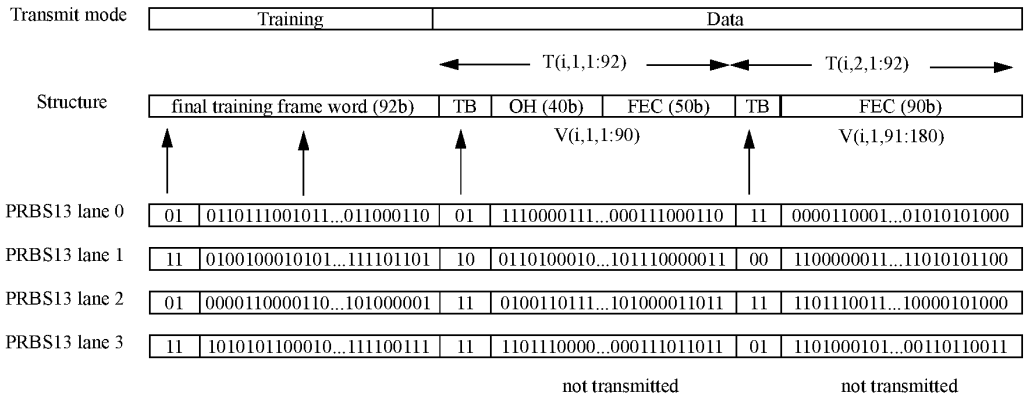


Figure 94–7—Transition from training to data mode

94.3.10.11 Training state diagram

The 10GBASE-KP4 PMD shall implement the training state diagram as depicted in Figure 72–5 including compliance with the associated state variables specified in 72.6.10.3. The training state diagram defines the operation of the 100GBASE-KP4 start-up protocol.

When the training state diagram enters the INITIALIZE state, the transmitter equalizer shall be configured such that the output meets the requirements of 94.3.12.5.4.

94.3.10.12 Coefficient update state diagram

For each tap, the 100GBASE-KP4 PMD shall implement an instance of the coefficient update state diagram in Figure 72–6 including compliance with the associated state variables as specified in 72.6.10.3. The coefficient update state diagram defines the process for updating transmit equalizer coefficients in response to requests from the link partner and also defines the coefficient update status to be reported in outgoing training frames.

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94.3.11 PMD LPI function

The PMD LPI function responds to the transitions between Active, Sleep, Quiet, Refresh, and Wake states via the PMD:IS_TX_MODE.request and PMD:IS_RX_MODE.request. Implementation of the function is optional. EEE capabilities and parameters are advertised during the Backplane Auto-negotiation, as described in 45.2.7.13. The transmitter on the local device informs the link partner's receiver when to sleep, refresh, and wake. The local receiver transitions are controlled by the link partner's transmitter and can change independent of the local transmitter states and transitions.

94.3.11.1 Alert Signal

During refresh and wake, to enable effective detection and quick receiver synchronization, an alert frame is sent prior to sending normal PMA frames. The alert signal is a series of repeating alert frames.

The alert frame shall be composed of a frame marker, control channel, and training pattern as depicted in Figure 94–8. The alert frame is based on the training frame specified in 94.3.10.2. The distinguishing differences are that the training pattern is truncated to 48 training frame words (4416 bits) and the coefficient update and status report fields are encoded differently. The alert frame is a total of 58 training frame words in length.

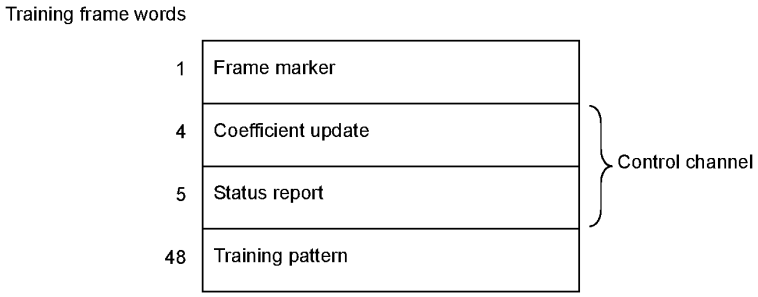


Figure 94–8—Alert frame structure

94.3.11.1.1 Frame marker

The frame marker shall be implemented as specified in 94.3.10.4.

94.3.11.1.2 Coefficient update field

The coefficient update field is unused in the alert frame. All bits in the coefficient update field are reserved and shall be transmitted as zeros.

94.3.11.1.3 Status report field

The status report field is used to signal state information from the local PMD to the link partner. The format of the status report field of alert frames shall be as shown in Table 94–10. Cell 19 of the status report field shall be transmitted first.

94.3.11.1.4 Parity

The parity field shall have the same behavior and purpose as specified for the training frame in 94.3.10.7.1.

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94.3.11.1.5 Mode

The mode field indicates whether the frame is a training frame (mode = 0) or an alert frame (mode = 1). This field differentiates the alert frame from a training frame. The mode field in the alert frame shall always indicate 1.

94.3.11.1.6 Alert frame countdown

The alert frame countdown field shall be updated as specified for the training frame in 94.3.10.7.2. The alert frame countdown may be used by the receiver to determine when the signal transitions from the alert frame to the PMA frame (see 94.3.11.1.9).

94.3.11.1.7 PMA alignment offset

The PMA alignment offset (PAO) shall indicate the relative position in the PMA frame in relation to the beginning of the next alert frame as described in this subclause. The PMA alignment offset may be used by the receiver to synchronize to the PMA frame without an additional frame synchronization process (see 94.3.11.1.9). The beginning of the PMA frame is defined as the termination block containing the PMA overhead (94.2.2.2).

The PMA frame length is exactly 6 times the alert frame length. The PMA alignment offset field indicates one of six offsets for the next alert frame within the PMA frame. The offset in number of training frame words of the next alert frame is determined by multiplying PMA alignment offset by 32. As a reference point, a PMA alignment offset of zero indicates that the start of the next alert frame is aligned with the start of a PMA frame. Valid values for the PMA alignment offset are {0,1,2,3,4,5}. The values {6,7} are not valid.

94.3.11.1.8 Receiver ready

The receiver ready cell shall always be set to 1 to indicate training is complete and the link is up.

94.3.11.1.9 Transition from alert to data

The transmitted signal shall transition from the alert signal to normal data as described in this subclause.

The transition from the alert signal to normal data occurs when the alert countdown is complete, as indicated by the alert frame countdown being equal to 0 (94.3.11.1.6). Immediately after the last bit of the last alert frame, transmission of the first PMA frame (94.2.2.4) begins with the termination block indicated by the PMA alignment offset, T(i,32*PAO,1:92). The PRBS13 generator used during alert to generate the training pattern is used to generate the termination bits in data mode. The state of the training PRBS13 generator is retained and 92 new bits are generated without reseeding or inverting. Termination bits are assigned and the PRBS13 generator continues to operate as specified in 94.2.2.4. The transition from alert to data mode and mapping of the PRBS13 to alert frame and termination bits is depicted in Figure 94–9. The values for the PRBS13 in Figure 94–9 are specific to a transition with a PAO of zero. The values are different for other PAO values.

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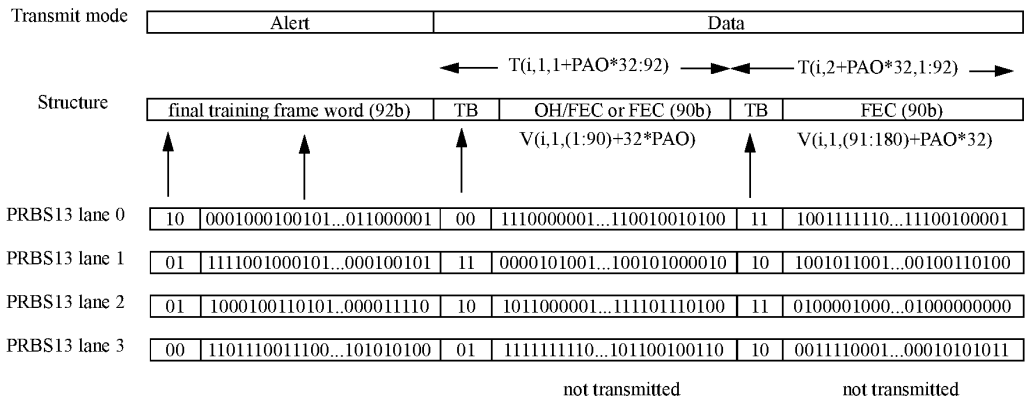


Figure 94–9—Transition from alert to data mode

94.3.12 PMD Transmitter electrical characteristics

Transmitter characteristics measured at TP0a are summarized in Table 94–13.

94.3.12.1 Test fixture

The test fixture of Figure 94–10 or its equivalent is required for measuring the transmitter specifications described in 94.3.12.

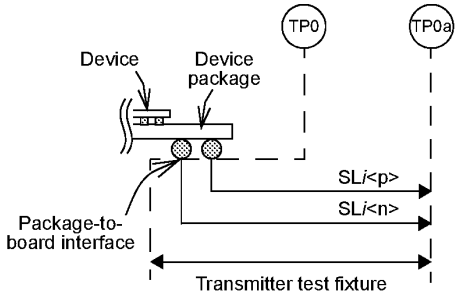


Figure 94–10—Transmitter test fixture and test points

94.3.12.1.1 Test fixture impedance

The differential load impedance applied to the transmitter output by the test fixture depicted in Figure 94–10 shall be 100 Ω.

The differential return loss, in dB with f in GHz, of the test fixture shall meet the requirement of Equation (94–4). The return loss limit $RL_{\min}(f)$ is shown Figure 94–11.

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Table 94–13—Summary of transmitter characteristics at TP0a

Parameter	Subclause reference	Value	Units
Signaling rate	94.3.12.2	13.59375 ± 100 ppm	GBd
Differential peak-to-peak output voltage (max.) Transmitter disabled Transmitter enabled	94.3.12.3	 30 1200	 mV mV
DC common-mode output voltage (max.)	94.3.12.3	1.9	V
DC common-mode output voltage (min.)	94.3.12.3	0	V
AC common-mode output voltage (RMS, max.)	94.3.12.3	30	mV
Differential output return loss (min.)	94.3.12.4	Equation (94–7)	dB
Common-mode output return loss (min.)	94.3.12.4	Equation (94–8)	dB
Output waveform Level separation mismatch ratio, R_{LM} (min) Steady-state voltage v_f (max.) Steady-state voltage v_f (min.) Linear fit pulse peak (min.) Normalized coefficient step size (min.) Normalized coefficient step size (max.) Pre-cursor full-scale range (min.) Post-cursor full-scale range (min.)	 94.3.12.5.1 94.3.12.5.3 94.3.12.5.3 94.3.12.5.3 94.3.12.5.5 94.3.12.5.5 94.3.12.5.6 94.3.12.5.6	 0.92 0.6 0.4 0.85 × v_f 0.0083 0.05 1.54 4	 — V V V — — — —
Output jitter and linearity Clock random jitter, RMS (max.) Clock deterministic jitter, peak-to-peak (max.) Even-odd jitter (max.) Signal-to-noise-and-distortion ratio (min.)	 94.3.12.6.1 94.3.12.6.1 94.3.12.6.2 94.3.12.7	 0.005 0.05 0.019 31	 UI UI UI dB

$$RL(f) \geq RL_{\min}(f) = \left\{ \begin{array}{ll} 20 - f & 0.05 \leq f \leq 5 \\ 15 & 5 < f \leq 13 \\ 20.57 - 0.4286f & 13 < f \leq 14 \end{array} \right\} \text{ (dB)} \quad (94\text{–}4)$$

The common-mode return loss, in dB, with f in GHz, of the test fixture shall meet the requirement of Equation (94–5). The return loss limit $RL_{\min}(f)$ is shown Figure 94–12.

$$RL(f) \geq RL_{\min}(f) = 10 \text{ (dB)} \qquad 0.05 \leq f \leq 14 \quad (94\text{–}5)$$

94.3.12.1.2 Test fixture insertion loss

The insertion loss of the test fixture measured at 12.89 GHz shall be between 1.2 dB and 1.6 dB.

The insertion loss deviation of the test fixture from 0.05 GHz to 10 GHz shall be less than 0.1 dB.

The reference insertion loss of the test fixture is defined by Equation (94–6), where f is the frequency in GHz, and is shown in Figure 94–13.

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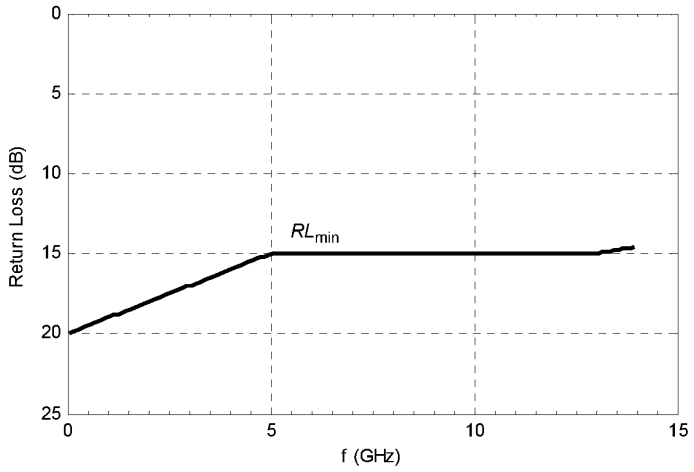


Figure 94–11—Test fixture differential return loss limit

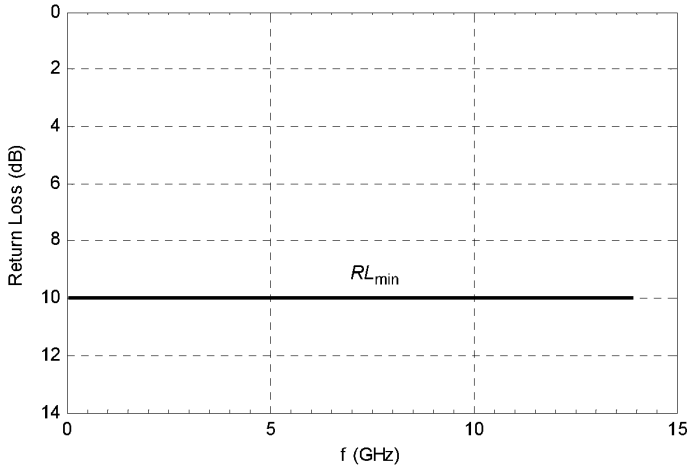


Figure 94–12—Test fixture common-mode return loss limit

$$IL_{ref}(f) = -0.0015 + 0.144\sqrt{f} + 0.069f \text{ (dB)} \qquad 0.05 \le f \le 14 \tag{94–6}$$

The effects of differences between the insertion loss of an actual test fixture and the reference insertion loss are to be accounted for in the measurements.

A test system with a fourth-order Bessel-Thomson low-pass response with 17 GHz 3 dB bandwidth is to be used for all transmitter signal measurements, unless otherwise specified.

94.3.12.2 Signaling rate and range

The 100GBASE-KP4 signaling rate shall be 13.59375 GBd ± 100 ppm per lane.

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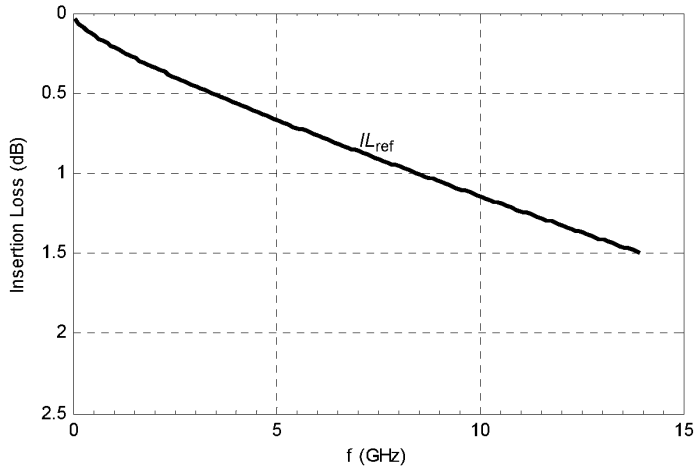


Figure 94–13—Test fixture reference insertion loss

94.3.12.3 Signal levels

The differential output voltage v_{di} is defined to be SL*i*<p> minus SL*i*<n>. The common-mode output voltage v_{cmi} is defined to be one half of the sum of SL*i*<p> and SL*i*<n>. These definitions are illustrated by Figure 94–14.

For a QPRBS13 test pattern (94.2.9.3), the peak-to-peak differential output voltage shall be less than or equal to 1200 mV regardless of the transmit equalizer setting. The peak-to-peak differential output voltage shall be less than or equal to 30 mV while the transmitter is disabled (refer to 94.3.6.6 and 94.3.6.7).

The DC common-mode output voltage shall be between 0 V and 1.9 V with respect to signal ground. The AC common-mode output voltage shall be less than or equal to 30 mV RMS with respect to signal ground. Common-mode output voltage requirements shall be met regardless of the transmit equalizer setting.

If the optional EEE deep sleep capability is supported, the following requirements also apply. The peak-to-peak differential output voltage shall be less than 30 mV within 500 ns of the transmitter being disabled.

When the transmitter transitions from disabled to enabled: (a) The amplitude of the frame marker of the third complete alert frame (see 94.3.11.1) after the transmitter is enabled shall be greater than 90% of the steady-state value (see 94.3.12.5.3), and (b) the transmitter output shall meet the requirements of 94.3.12 within 1 µs of the transmitter being enabled.

While the transmitter is disabled, the DC common-mode output voltage shall be maintained to within ±150 mV of the value for the enabled transmitter.

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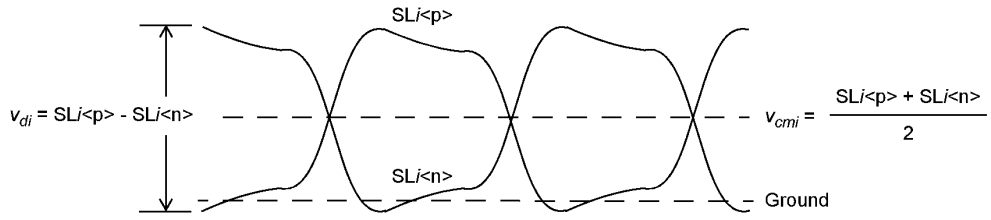


Figure 94–14—Transmitter output voltage definitions

94.3.12.4 Transmitter output return loss

The differential output return loss, in dB, of the transmitter shall meet Equation (94–7), where f is the frequency in GHz. The return loss limit $RL_{\min}(f)$ is shown Figure 94–15. This output impedance requirement applies to all valid output levels. The reference impedance for differential return loss measurements shall be 100 Ω

$$RL(f) \geq RL_{\min}(f) = \left\{ \begin{array}{ll} 12.05 - f & 0.05 \leq f \leq 6 \\ 6.5 - 0.075f & 6 < f \leq 10 \end{array} \right\} \quad \text{(dB)} \qquad (94\text{–}7)$$

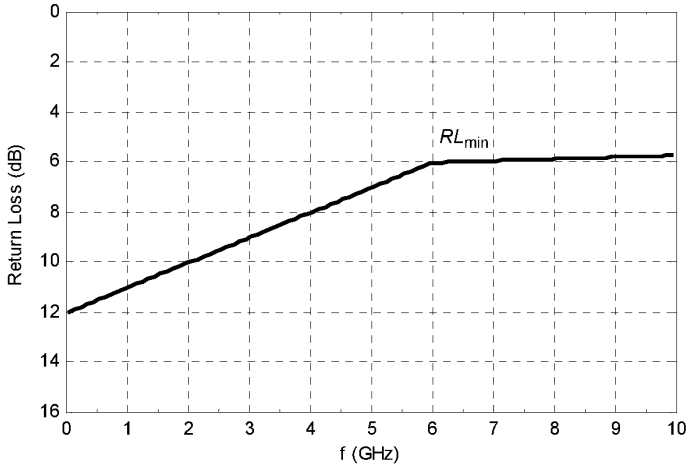


Figure 94–15—Transmitter differential return loss limit

The common-mode output return loss, in dB, of the transmitter shall meet Equation (94–8), where f is the frequency in GHz. The return loss limit $RL_{\min}(f)$ is shown Figure 94–16. This output impedance requirement applies to all valid output levels. The reference impedance for common-mode return loss measurements shall be 25 Ω.

$$RL(f) \geq RL_{\min}(f) = \left\{ \begin{array}{ll} 9.05 - f & 0.05 \leq f \leq 6 \\ 3.5 - 0.075f & 6 < f \leq 10 \end{array} \right\} \quad \text{(dB)} \qquad (94\text{–}8)$$

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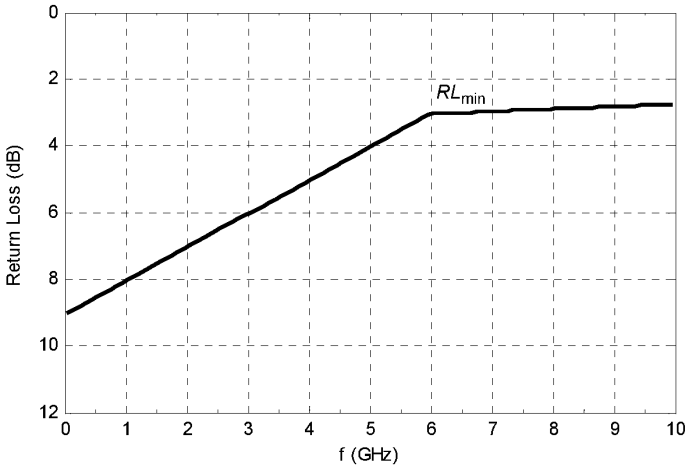


Figure 94–16—Transmitter common-mode return loss limit

94.3.12.5 Transmitter output waveform

The 100GBASE-KP4 transmit function includes programmable equalization to compensate for the frequency-dependent loss of the channel and facilitate data recovery at the receiver. The functional model for the transmit equalizer is the three tap transversal filter shown in Figure 94–17.

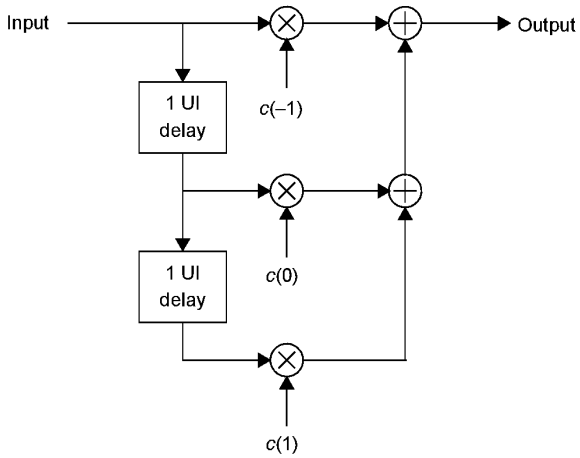


Figure 94–17—Transmit equalizer functional model

The state of the transmit equalizer and hence the transmitted output waveform may be manipulated via the PMD control function defined in 94.3.10 or via the management interface. The transmit function responds to a set of commands issued by the link partner's receive function and conveyed by a back-channel communications path.

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This command set includes instructions to:

Increment coefficient $c(i)$.
Decrement coefficient $c(i)$.
Hold coefficient $c(i)$ at its current value.
Set the coefficients to a predefined value (preset or initialize).

In response, the transmit function relays status information to the link partner's receive function. The status messages indicate that:

The requested update to coefficient $c(i)$ has completed (updated).
Coefficient $c(i)$ is at its minimum value.
Coefficient $c(i)$ is at its maximum value.
Coefficient $c(i)$ is ready for the next update request (not_updated).

94.3.12.5.1 Transmitter linearity

Transmitter linearity is measured using the transmitter linearity test pattern (see 94.2.9.4).

The resulting waveform is shown in Figure 94–18. Each measured level, V_A, V_B, V_C, and V_D, is measured within a 2 UI period starting 7 UI after the last level transition time. The minimum signal level, S_{min}, effective symbol levels ES_1 and ES_2, and level separation mismatch ratio, R_{LM}, are calculated based on Equation (94–9), Equation (94–10), Equation (94–11), Equation (94–12), and Equation (94–13), respectively.

The level separation mismatch ratio shall be greater than 0.92.

$$S_{\text{min}} = \frac{\min(V_D - V_C, V_C - V_B, V_B - V_A)}{2} \tag{94–9}$$

$$V_{\text{avg}} = \frac{V_A + V_B + V_C + V_D}{4} \tag{94–10}$$

$$ES_1 = \frac{V_B - V_{\text{avg}}}{V_A - V_{\text{avg}}} \tag{94–11}$$

$$ES_2 = \frac{V_C - V_{\text{avg}}}{V_D - V_{\text{avg}}} \tag{94–12}$$

$$R_{\text{LM}} = \frac{6 \cdot S_{\text{min}}}{V_D - V_A} \tag{94–13}$$

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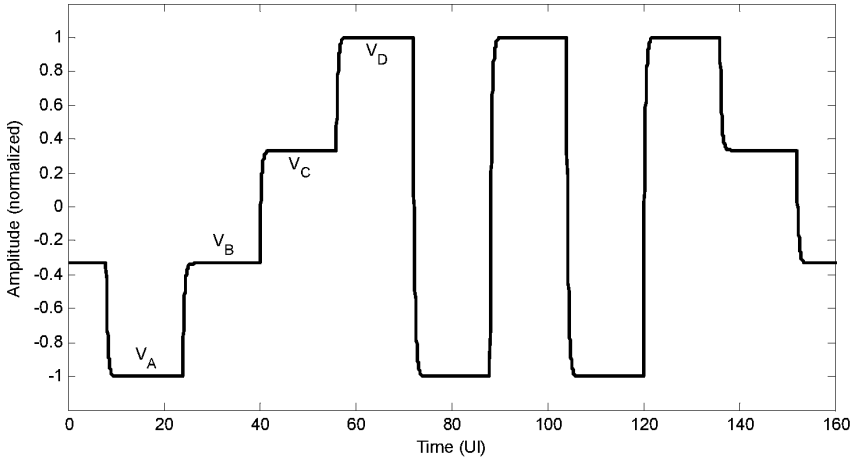


Figure 94–18—Transmitter linearity test pattern

94.3.12.5.2 Linear fit to the measured waveform

The following test procedure shall be followed to determine the linear fit pulse response, linear fit error, and normalized transmitter coefficient values.

For each configuration of the transmit equalizer, capture at least one complete cycle of the QPRBS13 test pattern (94.2.9.3) at TP0a per 85.8.3.3.4.

Compute the linear fit pulse response $p(k)$ from the captured waveform per 85.8.3.3.5 using $N_p = 16$ and $D_p = 2$. For aligned symbol values x(n) use –1, $-ES_1$, ES_2, and 1 to represent symbol values of 0, 1, 2, and 3, respectively, and where ES_1 and ES_2 are the effective symbol levels determined in 94.3.12.5.1.

Define $r(k)$ to be the linear fit pulse response when transmit equalizer coefficients have been set to the "preset" values (72.6.10.2.3.1).

For each configuration of the transmit equalizer, compute the normalized transmit equalizer coefficients, $c(i)$, according to 92.8.3.5.1.

94.3.12.5.3 Steady-state voltage and linear fit pulse peak

The linear fit pulse, $p(k)$, is determined according to the linear fit procedure in 94.3.12.5.2. The steady-state voltage v_f is defined to be the sum of the linear fit pulse $p(k)$ divided by M, determined in step 3 of the linear fit procedure.

The steady-state voltage shall be greater than or equal to 0.4 V and less than or equal to 0.6 V.

The peak value of $p(k)$ shall be greater than $0.85 \times v_f$.

94.3.12.5.4 Coefficient initialization

When the PMD enters the INITIALIZE state of the Training state diagram (Figure 72–5) or receives a valid request to "initialize" from the link partner, the coefficients of the transmit equalizer shall be configured such that the ratio (c(0)+c(1)–c(–1))/(c(0)+c(1)+c(–1)) is 1.29 ±10%, the ratio

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(c(0)–c(1)+c(–1))/(c(0)+c(1)+c(–1)) is 2.57 ±10%, and the steady-state voltage, v_f, (see 94.3.12.5) is greater than or equal to 140 mV. These requirements apply upon the assertion of a coefficient status report of "updated" for all coefficients.

94.3.12.5.5 Coefficient step size

The normalized amplitude of each coefficient $c(i)$ is determined according to the linear fit procedure in 94.3.12.5.2.

The change in the normalized amplitude of coefficient $c(i)$ corresponding to a request to "increment" that coefficient shall be between 0.0083 and 0.05. The change in the normalized amplitude of coefficient $c(i)$ corresponding to a request to "decrement" that coefficient shall be between –0.05 and –0.0083.

The change in the normalized amplitude of the coefficient is defined to be the difference in the value measured prior to the assertion of the "increment" or "decrement" request (e.g., the coefficient update request for all coefficients is "hold") and the value upon the assertion of a coefficient status report of "updated" for that coefficient.

94.3.12.5.6 Coefficient range

When sufficient "increment" or "decrement" requests have been received for a given coefficient, the coefficient reaches a lower or upper bound based on the coefficient range or restrictions placed on the minimum steady-state differential output voltage or the maximum peak-to-peak differential output voltage.

With $c(-1)$ set to zero and both $c(0)$ and $c(1)$ having received sufficient "decrement" requests so that they are at their respective minimum values, the ratio $(c(0)–c(1))/(c(0)+c(1))$ shall be greater than or equal to 4.

With $c(1)$ set to zero and both $c(-1)$ and $c(0)$ having received sufficient "decrement" requests so that they are at their respective minimum values, the ratio $(c(0)–c(-1))/(c(0)+c(-1))$ shall be greater than or equal to 1.54.

Note that a coefficient may be set to zero by first asserting the preset control and then manipulating the other coefficients as required by the test.

94.3.12.6 Transmitter output jitter

Jitter measurements in this subclause are performed with transmitters on all PMD lanes enabled and transmitting the same pattern with identical transmit equalizer settings.

94.3.12.6.1 Clock random jitter and clock deterministic jitter

Clock random jitter (CRJrms) measured at the transmitter output using the methodology described in this subclause shall be less than 0.005 UI RMS regardless of transmit equalization setting.

Clock deterministic jitter (CDJ) measured at the transmitter output using the methodology described in this subclause shall be less than 0.05 UI peak-to-peak regardless of transmit equalization setting.

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133. Physical Coding Sublayer (PCS) for 64B/66B, type 50GBASE-R

133.1 Overview

133.1.1 Scope

This clause specifies the Physical Coding Sublayer (PCS) that is common to a family of 50 Gb/s Physical Layer implementations known as 50GBASE-R. The 50GBASE-R PCS is a sublayer of the 50 Gb/s PHYs listed in Table 131–1.

133.1.2 Relationship of 50GBASE-R to other standards

Figure 133–1 depicts the relationships among the 50GBASE-R sublayers, the Ethernet MAC and Reconciliation Sublayers, and the higher layers.

The 50GBASE-R PCS is identical to the 40GBASE-R PCS specified in Clause 82 with the following exceptions:

1) The nominal rate at the FEC or PMA service interface is 12.890625 Gb/s per PCS lane, rather than 10.3125 Gb/s per PCS lane.
2) The alignment marker spacing is modified such that alignment markers are inserted after every 20 479 66-bit blocks on each PCS lane, rather than after every 16 383 66-bit blocks on each PCS lane as described in 82.2.7.
3) The definitions of "current_am", "am_counter", "ber_cnt" and "xus_timer" in the state diagrams defined in 82.2.19 are modified to support the different alignment marker spacing and the different data rate.
4) The optional EEE deep sleep capability is not supported.

133.1.3 Summary of 50GBASE-R sublayers

Figure 133–1 shows the relationship of the 50GBASE-R PCS sublayer (shown shaded) with other sublayers to the ISO Open System Interconnection (OSI) reference model.

133.1.3.1 Physical Coding Sublayer (PCS)

The PCS service interface is the 50GMII, which is defined in Clause 132. The 50GMII provides a uniform interface to the Reconciliation Sublayer for all 50 Gb/s PHY implementations

The 50GBASE-R PCS provides all services required by the 50GMII.

133.1.4 Inter-sublayer interfaces

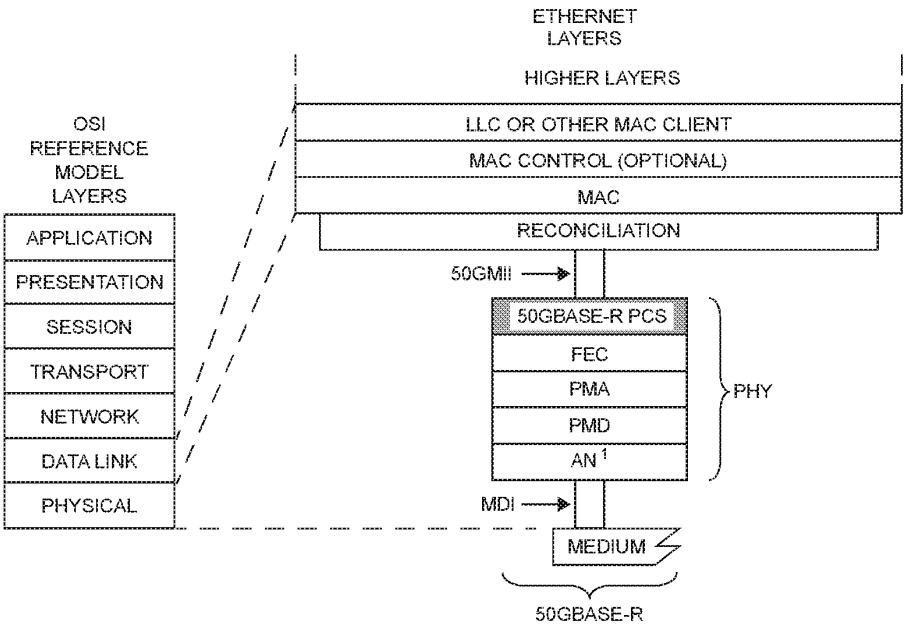
The upper interface of the PCS may connect to the Reconciliation Sublayer through the 50GMII.

The lower interface of the PCS connects to the FEC sublayer. If the optional LAUI-2 interface (see 135B.1 and 135C.1) is physically instantiated directly below the PCS sublayer, then the lower interface of the PCS instead connects to the PMA. The 50GBASE-R PCS is based on 4 PCS lanes and has a nominal rate at the FEC or PMA service interface of 12.890625 Gb/s per PCS lane, which provides capacity for the MAC data rate of 50Gb/s.

It is important to note that, while this specification defines interfaces in terms of bits, octets, and frames, implementations may choose other data-path widths for implementation convenience.

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50GMII = 50 Gb/s MEDIA INDEPENDENT INTERFACE
AN = AUTO-NEGOTATION
LLC = LOGICAL LINK CONTROL
MAC = MEDIA ACCESS CONTROL
MDI = MEDIUM DEPENDENT INTERFACE
PCS = PHYSICAL CODING SUBLAYER
PHY = PHYSICAL LAYER DEVICE
PMA = PHYSICAL MEDIUM ATTACHMENT
PMD = PHYSICAL MEDIUM DEPENDENT
FEC = FORWARD ERROR CORRECTION

NOTE 1—CONDITIONAL BASED ON PHY TYPE

Figure 133–1—50GBASE-R PCS relationship to the ISO/IEC Open Systems Interconnection (OSI) reference model and IEEE 802.3 Ethernet model

133.1.4.1 PCS service interface (50GMII)

The PCS service interface allows the 50GBASE-R PCS to transfer information to and from a PCS client. The PCS client is the Reconciliation Sublayer. The PCS Service Interface is defined as the 50GMII in Clause 132.

133.1.4.2 Forward Error Correction (FEC) or Physical Medium Attachment (PMA) service interface

The FEC or PMA service interface for the PCS is described in an abstract manner and does not imply any particular implementation. The FEC or PMA Service Interface supports the exchange of encoded data between the PCS and the FEC or PMA sublayer. The FEC service interface is defined in 134.2. The PMA service interface is defined in 135.3.

133.1.5 Functional block diagram

Figure 133–2 provides a functional block diagram of the 50GBASE-R PCS.

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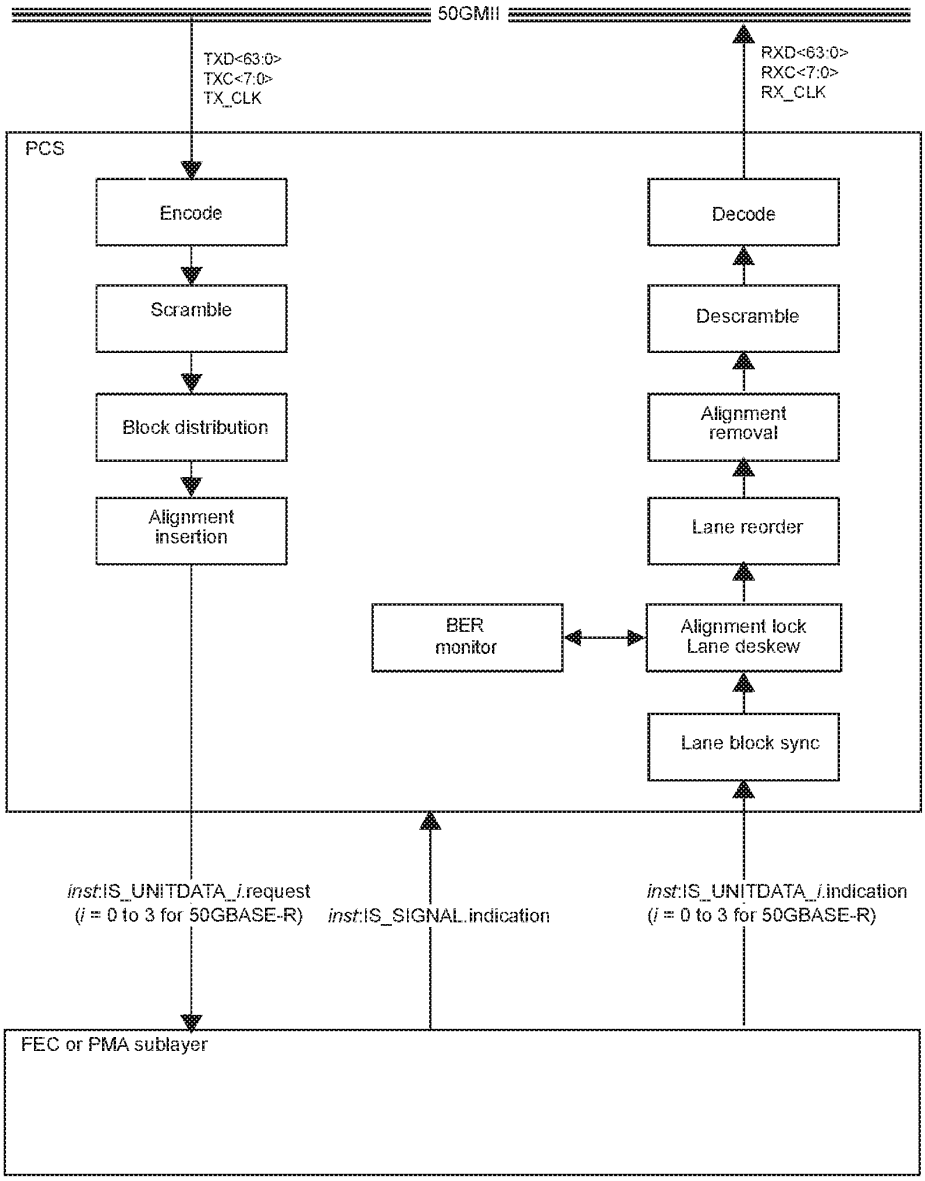


Figure 133–2—50GBASE-R PCS functional block diagram

133.2 Physical Coding Sublayer (PCS)

133.2.1 Functions within the PCS

The 50GBASE-R PCS shall have all of the functionality of the 40GBASE-R PCS specified in Clause 82 with the following exceptions:

1) The nominal rate at the FEC or PMA service interface is 12.890625 Gb/s per PCS lane, rather than 10.3125 Gb/s per PCS lane.

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2) The alignment marker spacing is modified such that alignment markers are inserted after every 20 479 66-bit blocks on each PCS lane, rather than after every 16 383 66-bit blocks on each PCS lane as described in 82.2.7. (See 133.2.2.)

3) The definition of "current_am", "am_counter" "ber_cnt" and "xus_timer" in the state diagrams defined in 82.2.19 are modified to account for the different alignment marker spacing and the different data rate. (See 133.2.4.)

4) The optional deep sleep mode of EEE is not supported.

133.2.2 Alignment marker insertion

The alignment marker insertion for the 50GBASE-R PCS is identical to the alignment marker insertion for the 40GBASE-R PCS described in 82.2.7, with the exception that the alignment markers shall be inserted after every 20 479 66-bit blocks on each PCS lane, rather than after every 16 383 66-bit blocks on each PCS lane as described in 82.2.7. Alignment marker insertion is illustrated in Figure 133–3 and Figure 133–4.

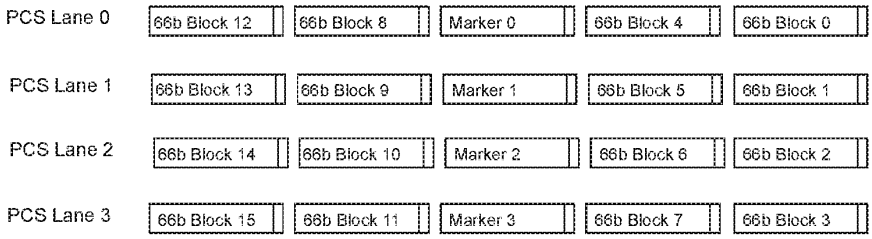


Figure 133–3—Alignment marker insertion

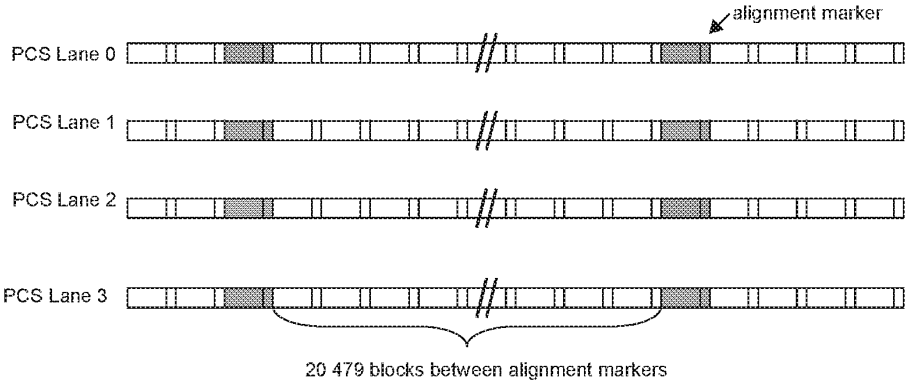


Figure 133–4—Alignment marker insertion period

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The format of the 50GBASE-R PCS alignment markers is identical to the format of the 40GBASE-R PCS alignment markers described in 82.2.7 and shown in Figure 82–9.

The content of the 50GBASE-R PCS alignment markers is identical to the content of the 40GBASE-R PCS alignment markers described in 82.2.7 and shown in Table 82–3.

133.2.3 PCS lane deskew

The 50GBASE-R PCS receiver shall support a maximum Skew of 49 ns and a maximum Skew Variation of 0.4 ns.

Skew and Skew Variation are defined in 131.5.

133.2.4 Detailed functions and state diagrams

The state diagrams are identical to those for the 40GBASE-R PCS defined in 82.2.19 with the exception that some variables, counters and timers are redefined as follows:

current_am
: This variable holds the lane number of the current alignment marker. This is compared to the variable first_am to determine if we have alignment marker lock and is always n × 20 480 66-bit blocks away from the first_am.

am_counter
: This counter counts 66-bit blocks that separate two consecutive alignment markers. The terminal count is 20 479.

ber_cnt
: This counter counts up to a maximum of 97 of the number of invalid sync headers within the current 1 ms period.

xus_timer
: Timer that is triggered every 1 ms +1%, –25%.

133.3 Delay constraints

The maximum delay contributed by the 50GBASE-R PCS (sum of transmit and receive delays at one end of the link) shall be no more than 11 264 BT (22 pause_quanta or 225.28 ns). A description of overall system delay constraints and the definitions for bit times and pause_quanta can be found in 131.4 and its references.

133.4 Auto-Negotiation

The following requirements apply to a PCS used with a 50GBASE-CR or 50GBASE-KR PMD where support for the Auto-Negotiation process defined in Clause 73 is mandatory. The PCS shall support the primitive AN_LINK.indication(link_status) (see 73.9). The parameter link_status shall take the value FAIL when PCS_status=false and the value OK when PCS_status=true. The primitive shall be generated when the value of link_status changes.

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133.5 Protocol implementation conformance statement (PICS) proforma for Clause 133, Physical Coding Sublayer (PCS) for 64B/66B, type 50GBASE-R[6]

133.5.1 Introduction

The supplier of a protocol implementation that is claimed to conform to Clause 133, Physical Coding Sublayer (PCS) for 64B/66B, type 50GBASE-R, shall complete the following protocol implementation conformance statement (PICS) proforma. A detailed description of the symbols used in the PICS proforma, along with instructions for completing the PICS proforma, can be found in Clause 21.

133.5.2 Identification

133.5.2.1 Implementation identification

Supplier[1]	
Contact point for inquiries about the PICS[1]	
Implementation Name(s) and Version(s)[1,3]	
Other information necessary for full identification—e.g., name(s) and version(s) for machines and/or operating systems; System Name(s)[2]	
NOTE 1—Required for all implementations. NOTE 2—May be completed as appropriate in meeting the requirements for the identification. NOTE 3—The terms Name and Version should be interpreted appropriately to correspond with a supplier's terminology (e.g., Type, Series, Model).	

133.5.2.2 Protocol summary

Identification of protocol standard	IEEE Std 802.3cd-201x, Clause 133, Physical Coding Sublayer (PCS) for 64B/66B, type 50GBASE-R
Identification of amendments and corrigenda to this PICS proforma that have been completed as part of this PICS	
Have any Exception items been required? No [ ] Yes [ ] (See Clause 21; the answer Yes means that the implementation does not conform to IEEE Std 802.3cd-201x.)	

Date of Statement	

[6]*Copyright release for PICS proformas:* Users of this standard may freely reproduce the PICS proforma in this subclause so that it can be used for its intended purpose and may further publish the completed PICS.

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133.5.3 Major capabilities/options

Item	Feature	Subclause	Value/Comment	Status	Support
PCS	Supports 50GBASE-R PCS functionality	133.1.1		M	Yes [ ]
XGE50	50GMII logical interface	132, 133.1.4	Logical interface is supported	O	Yes [ ] No [ ]
*MD	MDIO	45, 82.3	Registers and interface supported	O	Yes [ ] No [ ]
PMA	Supports operation directly connected to a PMA	133.1.4.2		O.1	Yes [ ] No [ ]
FEC	Supports operation directly connected to a FEC sublayer	133.1.4.2		O.1	Yes [ ] No [ ]
*JTM	Supports test-pattern mode	82.2.1		PMA:M	Yes [ ] N/A[ ]

133.5.4 PICS Proforma Tables for Physical Coding Sublayer (PCS) for 64B/66B, type 50GBASE-R

133.5.4.1 Coding rules

Item	Feature	Subclause	Value/Comment	Status	Support
C1	Encoder (and ENCODE function) implements the code as specified	82.2.3 and 82.2.19.2.3		M	Yes [ ]
C2	Decoder (and DECODE function) implements the code as specified	82.2.3 and 82.2.19.2.3		M	Yes [ ]
C3	Only valid block types are transmitted	82.2.3.3		M	Yes [ ]
C4	Invalid block types are treated as an error	82.2.3.3		M	Yes [ ]
C5	Only valid control characters are transmitted	82.2.3.4		M	Yes [ ]
C6	Invalid control characters are treated as an error	82.2.3.4		M	Yes [ ]
C7	Idles do not interrupt data	82.2.3.6		M	Yes [ ]
C8	IDLE control code insertion and deletion	82.2.3.6	Insertion or Deletion in groups of 8 /I/s	M	Yes [ ]
C9	Sequence ordered set deletion	82.2.3.9	Only one whole ordered set of two consecutive sequence ordered sets may be deleted	M	Yes [ ]

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133.5.4.2 Scrambler and Descrambler

Item	Feature	Subclause	Value/Comment	Status	Support
S1	Scrambler	82.2.5	Performs as shown in Figure 49–8	M	Yes [ ]
S2	Descrambler	82.2.16	Performs as shown in Figure 49–10	M	Yes [ ]

133.5.4.3 Deskew and Reordering

Item	Feature	Subclause	Value/Comment	Status	Support
DR1	Deskew	82.2.13, 133.2.3	Able to deskew up to the value in 133.2.3.	M	Yes [ ]
DR2	Reordering	82.2.14	Performs reordering.	M	Yes [ ]

133.5.4.4 Alignment Markers

Item	Feature	Subclause	Value/Comment	Status	Support
AM1	Alignment marker insertion	133.2.2	Alignment markers are inserted periodically as described in section 133.2.2	M	Yes [ ]
AM2	Alignment marker format	133.2.2	Alignment markers are formed as described in Figure 82–9 and Table 82–3	M	Yes [ ]
AM3	Lane mapping	82.2.19.3	PCS lane number is captured	MD:M	Yes [ ] N/A [ ]

133.5.4.5 Test-pattern modes

Item	Feature	Subclause	Value/Comment	Status	Support
JT1	Scrambled idle transmit test-pattern generator is implemented	82.2.11	Performs as in 82.2.11	JTM:M	Yes [ ] N/A[ ]
JT2	Scrambled idle receive test-pattern checker is implemented	82.2.18	Performs as in 82.2.18	JTM:M	Yes [ ] N/A[ ]
JT3	Transmit and receive test-pattern modes can operate simultaneously	82.2.1		JTM:M	Yes [ ] N/A[ ]

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133.5.4.6 Bit order

Item	Feature	Subclause	Value/Comment	Status	Support
B1	Transmit bit order	133.2.1, 82.2.3.2	Placement of bits into the PCS lanes as shown in Figure 82–3.	M	Yes [ ]
B2	Receive bit order	133.2.1, 82.2.3.2	Placement of bits into the 50GMII as shown in Figure 82–4	M	Yes [ ]

133.5.4.7 Management

Item	Feature	Subclause	Value/Comment	Status	Support
M1	Alternate access to PCS Management objects is provided	82.3		O	Yes [ ] No [ ]

133.5.4.8 State diagrams

Item	Feature	Subclause	Value/Comment	Status	Support
SM1	50GBASE-R Block Lock	133.2.4	Implements 4 block lock processes as depicted in Figure 82–12	M	Yes [ ]
SM2	The SLIP function evaluates all possible bit positions	133.2.4		M	Yes [ ]
SM3	50GBASE-R Alignment Marker Lock	133.2.4	Implements 4 alignment marker lock processes as depicted in Figure 82–13	M	Yes [ ]
SM4	The AM_SLIP functions evaluates all possible blocks	133.2.4		M	Yes [ ]
SM5	50GBASE-R PCS deskew state diagram	133.2.4	Meets the requirements of Figure 82–14	M	Yes [ ]
SM6	50GBASE-R BER Monitor	133.2.4	Meets the requirements of Figure 82–15 with xus_timer_done set to 1 ms	M	Yes [ ]
SM7	50GBASE-R Transmit process	133.2.4	Meets the requirements of Figure 82–16	M	Yes [ ]
SM8	50GBASE-R Receive process	133.2.4	Meets the requirements of Figure 82–17	M	Yes [ ]

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133.5.4.9 Loopback

Item	Feature	Subclause	Value/Comment	Status	Support
L1	Supports loopback	82.4	Performs as in 82.4	M	Yes [ ]
L2	When in loopback, transmits what it receives from the 50GMII	82.4	Performs as in 82.4	M	Yes [ ]

133.5.4.10 Delay constraints

Item	Feature	Subclause	Value/Comment	Status	Support
TIM1	PCS Delay Constraint	133.3	No more than 11 264 BT for sum of transmit and receive path delays for 50GBASE-R	M	Yes [ ]

133.5.4.11 Auto-Negotiation for Backplane Ethernet functions

Item	Feature	Subclause	Value/Comment	Status	Support
*AN	Support for use with a 50GBASE-CR or 50GBASE-KR PMD	82.6	AN technology dependent interface described in Clause 73	O	Yes [ ] No [ ]
AN1	AN_LINK.indication primitive	82.6	Support of the primitive AN_LINK.indication(link_status)	AN:M	Yes [ ] N/A[ ]
AN2	link_status parameter	82.6	Takes the value OK or FAIL, as described in 82.6	AN:M	Yes [ ] N/A[ ]
AN2	Generation of AN_LINK.indication primitive	82.6	Generated when the value of link_status changes	AN:M	Yes [ ] N/A[ ]

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136. Physical Medium Dependent (PMD) sublayer and baseband medium, type 50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4

136.1 Overview

This clause specifies the 50GBASE-CR PMD, the 100GBASE-CR2 PMD, the 200GBASE-CR4 PMD, and the baseband medium. The specifications for the three PMDs are similar, except for the number of lanes and associated parameters and the MDI.

There are three associated annexes. Annex 136A provides information on parameters with test points that may not be testable in an implemented system. Annex 136B specifies test fixtures. Annex 136C describes 50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4 host and cable assembly form factors.

When forming a complete Physical Layer, a PMD shall be connected as illustrated in Figure 136–1, to the appropriate sublayers (as specified in Table 136–1, Table 136–2, and Table 136–3), to the medium through the appropriate MDI, and to the management functions that are optionally accessible through the management interface defined in Clause 45, or equivalent.

Table 136–1—Physical Layer clauses associated with the 50GBASE-CR PMD

Associated clause	50GBASE-CR
132—RS	Required
132—50GMII[a]	Optional
133—PCS for 50GBASE-R	Required
134—RS-FEC	Required
135—PMA for 50GBASE-R	Required
135B—LAUI-2 C2C	Optional
135D—50GAUI-2 C2C	Optional
135F—50GAUI-1 C2C	Optional
73—Auto-Negotiation	Required
78—Energy Efficient Ethernet	Optional

[a]The 50GMII is an optional interface. However, if the 50GMII is not implemented, a conforming implementation must behave functionally as though the RS and 50GMII were present.

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Table 136–2—Physical Layer clauses associated with the 100GBASE-CR2 PMD

Associated clause	100GBASE-CR2
80—RS	Required
80—CGMII[a]	Optional
82—PCS for 100GBASE-R	Required
91—RS-FEC	Required
83—PMA for 100GBASE-R	Optional[b]
83A—CAUI-10	Optional
83D—CAUI-4 C2C	Optional
135—PMA for 100GBASE-P	Required
135D—100GAUI-4 C2C	Optional
135F—100GAUI-2 C2C	Optional
73—Auto-Negotiation	Required
78—Energy Efficient Ethernet	Optional

[a]The CGMII is an optional interface. However, if the CGMII is not implemented, a conforming implementation must behave functionally as though the RS and CGMII were present.
[b]PMA for 100GBASE-R is required when either CAUI-10 or CAUI-4 is used.

Table 136–3—Physical Layer clauses associated with the 200GBASE-CR4 PMD

Associated clause	200GBASE-CR4
117—RS	Required
117—200GMII[a]	Optional
119—PCS for 200GBASE-R	Required
120—PMA for 200GBASE-R	Required
120B—200GAUI-8 C2C	Optional
120D—200GAUI-4 C2C	Optional
73—Auto-Negotiation	Required
78—Energy Efficient Ethernet	Optional

[a]The 200GMII is an optional interface. However, if the 200GMII is not implemented, a conforming implementation must behave functionally as though the RS and 200GMII were present.

For the 50GBASE-CR and 100GBASE-CR2 PHYs, in order to support the required frame loss ratio (see 1.4.223) of less than 6.2×10^{-10} for 64-octet frames with minimum interpacket gap, the PMD and the adjacent PMA are required to detect bits from a compliant input signal at a BER lower than 2.4×10^{-4} assuming errors are sufficiently uncorrelated. This BER allocation enables a frame loss ratio lower than 10^{-10} after processing by the RS-FEC (Clause 134 or Clause 91) and the PCS (Clause 133 or Clause 82) if there are negligible errors due to other electrical interfaces (50GAUI-n or 100GAUI-n). If the PMD and

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PMA create errors that are not sufficiently uncorrelated, the BER is required to be lower as appropriate to maintain a frame loss ratio lower than 10^{-10}.

For the 200GBASE-CR4 PHY, in order to support the required frame loss ratio (see 1.4.223) of less than 6.2×10^{-11} for 64-octet frames with minimum interpacket gap, the PMD and the adjacent PMA are required to detect bits from a compliant input signal at a BER lower than 2.4×10^{-4} assuming errors are sufficiently uncorrelated. This BER allocation enables a frame loss ratio lower than 9.2×10^{-13} after processing by the PCS (Clause 119) if there are negligible errors due to other electrical interfaces (200GAUI-n). If the PMD and PMA create errors that are not sufficiently uncorrelated, the BER is required to be lower as appropriate to maintain a frame loss ratio lower than 9.2×10^{-13}.

A compliant input signal is a transmitter output of a compliant PHY that has passed through a compliant cable assembly.

50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4 PHYs with the optional Energy-Efficient Ethernet (EEE) fast wake capability may enter the Low Power Idle (LPI) mode to conserve energy during periods of low link utilization (see Clause 78). The deep sleep mode of EEE is not supported.

Figure 136–1 shows the relationship of the 50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4 PMD sublayers and MDIs to the ISO/IEC Open System Interconnection (OSI) reference model.

136.2 Conventions

Clause 136 describes three PMDs, 50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4 PMD, which have one, two, and four lanes, respectively. For efficient description, the parameter n is used to describe the number of lanes in a specific PMD. Accordingly, n = 1 for 50GBASE-CR, n = 2 for 100GBASE-CR2, and n = 4 for 200GBASE-CR4.

The parameter *i* is used as an index or a suffix to identify a specific lane, and takes the values 0 to n – 1.

Within this clause, the unqualified term "PMD" refers to any of 50GBASE-CR PMD, 100GBASE-CR2 PMD, or 200GBASE-CR4 PMD.

136.3 PMD service interfaces

This subclause specifies the services provided by the 50GBASE-CR, 100GBASE-CR2 and 200GBASE-CR4 PMDs. The service interfaces for these PMDs are described in an abstract manner and do not imply any particular implementation. The PMD service interface supports the exchange of encoded data between the PMA entity that resides just above the PMD, and the PMD entity. The PMD translates the encoded data to and from signals suitable for the specified medium.

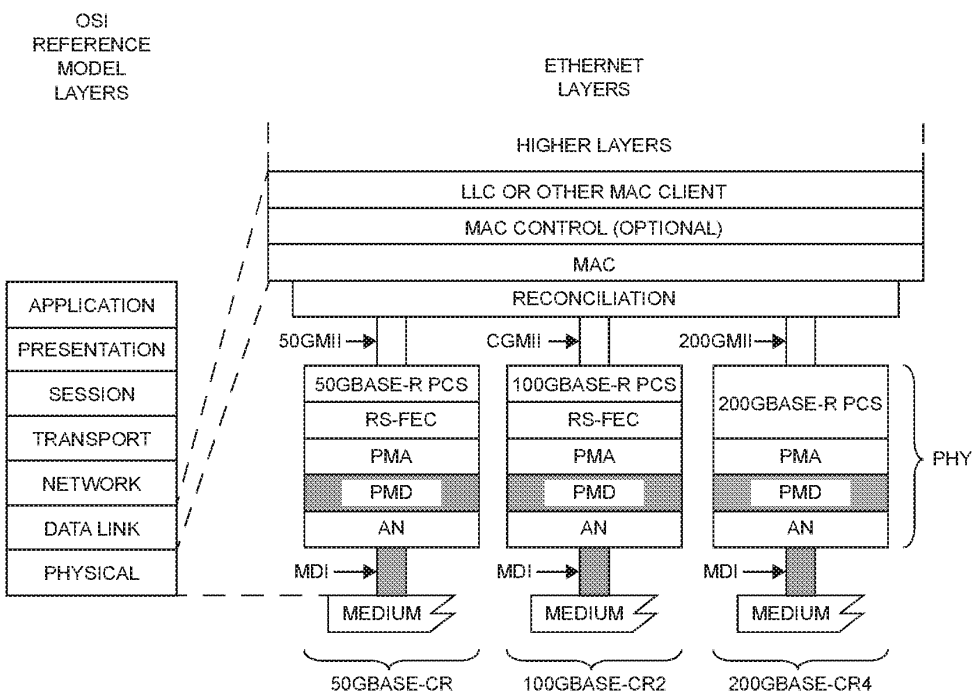
The 50GBASE-CR PMD service interface is an instance of the inter-sublayer service interface defined in 131.3, with a single symbol stream (n = 1).

The 100GBASE-CR2 PMD service interface is an instance of the inter-sublayer service interface defined in 116.3, with the exception that there are two parallel symbol streams (n = 2).

The 200GBASE-CR4 PMD service interface is an instance of the inter-sublayer service interface defined in 116.3, with four parallel symbol streams (n = 4).

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200GMII = 200 Gb/s MEDIA INDEPENDENT INTERFACE
50GMII = 50 Gb/s MEDIA INDEPENDENT INTERFACE
AN = AUTO-NEGOTATION
CGMII = 100 Gb/s MEDIA INDEPENDENT INTERFACE
LLC = LOGICAL LINK CONTROL
MAC = MEDIA ACCESS CONTROL
MDI = MEDIUM DEPENDENT INTERFACE
MAC = MEDIA ACCESS CONTROL
PCS = PHYSICAL CODING SUBLAYER
PHY = PHYSICAL LAYER DEVICE
PMA = PHYSICAL MEDIUM ATTACHMENT
PMD = PHYSICAL MEDIUM DEPENDENT
RS-FEC = REED-SOLOMON FORWARD ERROR CORRECTION

Figure 136–1—50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4 relationship to the ISO/IEC Open Systems Interconnection (OSI) reference model and the IEEE 802.3 Ethernet model

The service interface primitives are summarized as follows:

PMD:IS_UNITDATA_*i*.request
PMD:IS_UNITDATA_*i*.indication
PMD:IS_SIGNAL.indication

The 50GBASE-SR PMD has a single symbol stream, hence $i = 0$.

The 100GBASE-SR2 PMD has two parallel symbol streams, hence $i = 0$ to 1.

The 200GBASE-SR4 PMD has four parallel symbol streams, hence $i = 0$ to 3.

In the transmit direction, the PMA continuously sends n streams of PAM4 symbols to the PMD, one per lane, using the PMD:IS_UNITDATA_*i*.request primitive, at a nominal signaling rate of 26.6525 GBd. The PMD converts these streams of symbols into appropriate signals on the MDI.

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In the receive direction, the PMD continuously sends *n* streams of PAM4 symbols to the PMA, corresponding to the signals received from the MDI, one per lane, using the PMD:IS_UNITDATA_*i*.indication primitive, at a nominal signaling rate of 26.6525 GBd.

The SIGNAL_OK parameter of the PMD:IS_SIGNAL.indication primitive corresponds to the variable Global_PMD_signal_detect as defined in 136.8.4. When Global_PMD_signal_detect is one, SIGNAL_OK shall be assigned the value OK. When Global_PMD_signal_detect is zero, SIGNAL_OK shall be assigned the value FAIL. When SIGNAL_OK is FAIL, the PMD:IS_UNITDATA_*i*.indication parameter is undefined.

136.4 PCS requirements for Auto-Negotiation (AN) service interface

The PCSs associated with the 50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4 PMDs are required to support the AN service interface primitive AN_LINK.indication defined in 73.9. (See 133.4, 82.6, and 119.6.)

50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4 PHYs may be extended using chip-to-chip (C2C) 50GAUI-n/LAUI-2, 100GAUI-n/CAUI-n, and 200GAUI-n, respectively, as physical instantiations of the inter-sublayer service interface between devices. If such extension is used, then the AN_LINK(link_status).indication is relayed from the device with the PCS sublayer to the device with the AN sublayer by means at the discretion of the implementer. As examples, the implementer may employ use of pervasive management or employ a dedicated electrical signal to relay the state of link_status as indicated by the PCS sublayer on one device to the AN sublayer on the other device.

136.5 Delay constraints

The sum of the transmit and the receive delays at one end of the link contributed by the PMD and AN **including the medium in one direction shall be no more than the maximum delays listed in Table 136–4.** It is assumed that the one-way delay through the medium is no more than 20 ns.

Table 136–4—Delay constraints

PMD	Maximum (bit times)[a]	Maximum (pause_quanta)[b]	Maximum (ns)
50GBASE-CR	2048	4	40.96
100GBASE-CR2	4096	8	40.96
200GBASE-CR4	8192	16	40.96

[a]One bit time is equal to 20 ps for 50GBASE-CR, 10 ps for 100GBASE-CR2, and 5 ps for 200GBASE-CR4. (See 1.4.117 for the definition of bit time.)
[b]One pause_quantum is equal to 10.24 ns for 50GBASE-CR, 5.12 ns for 100GBASE-CR2, and 2.56 ns for 200GBASE-CR4. (See 31B.2 for the definition of pause_quanta.)

Descriptions of overall system delay constraints can be found in 131.4 for 50GBASE-CR, in 80.4 for 100GBASE-CR2, and in 116.4 for 200GBASE-CR4.

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136.6 Skew constraints

The Skew (relative delay) between the PCS or FEC lanes must be kept within limits so that the information on the PCS or FEC lanes can be reassembled by the PCS or FEC. The Skew Variation must also be limited to ensure that a given PCS or FEC lane always traverses the same physical lane.

136.6.1 Skew Constraints for 50GBASE-CR

Skew and Skew Variation are defined in 131.5 and specified at the points SP0 to SP7 shown in Figure 131–3.

If the PMD service interface is physically instantiated so that the Skew at SP2 can be measured, then the Skew at SP2 is limited to 43 ns as defined by 135.5.3.5. Since the signal at the PMD service interface represents a serial bit stream, there is no Skew Variation at this point.

The Skew at SP3 (the transmitter MDI) shall be less than 54 ns. Since the signal at the MDI represents a serial bit stream, there is no Skew Variation at this point.

The Skew at SP4 (the receiver MDI) shall be less than 134 ns. Since the signal at the MDI represents a serial bit stream, there is no Skew Variation at this point.

If the PMD service interface is physically instantiated so that the Skew at SP5 can be measured, then the Skew at SP5 shall be less than 145 ns. Since the signal at the PMD service interface represents a serial bit stream, there is no Skew Variation at this point.

For more information on Skew and Skew Variation, see 131.5. The measurements of Skew and Skew Variation are defined in 89.7.2.

136.6.2 Skew Constraints for 100GBASE-CR2 and 200GBASE-CR4

Skew and Skew Variation are defined in 80.5 and 116.5 and specified at the points SP1 to SP6 shown in Figure 80–8 and Figure 116–5.

If the PMD service interface is physically instantiated so that the Skew at SP2 can be measured, then the Skew at SP2 is limited to 43 ns and the Skew Variation at SP2 is limited to 400 ps.

The Skew at SP3 (the transmitter MDI) shall be less than 54 ns and the Skew Variation at SP3 shall be less than 600 ps.

The Skew at SP4 (the receiver MDI) shall be less than 134 ns and the Skew Variation at SP4 shall be less than 3.4 ns.

If the PMD service interface is physically instantiated so that the Skew at SP5 can be measured, then the Skew at SP5 shall be less than 145 ns and the Skew Variation at SP5 shall be less than 3.6 ns.

For more information on Skew and Skew Variation see 80.5 and 116.5.

136.7 PMD MDIO function mapping

The optional MDIO capability described in Clause 45 defines several registers that provide control and status information for and about the PMD. If MDIO is implemented, it shall map MDIO control bits to PMD

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control variables as shown in Table 136–5, and MDIO status bits to PMD status variables as shown in Table 136–6.

Table 136–5—MDIO/PMD control variable mapping

MDIO control variable	PMA/PMD register name	Register/bit number	PMD control variable
Reset	PMA/PMD control 1	1.0.15	PMD_reset
Global PMD transmit disable	PMD transmit disable	1.9.0	Global_PMD_transmit_disable
PMD transmit disable 3 to PMD transmit disable 2[a]	PMD transmit disable	1.9.4:3	PMD_transmit_disable_3, PMD_transmit_disable_2
PMD transmit disable 1[b]	PMD transmit disable	1.9.2	PMD_transmit_disable_1
PMD transmit disable 0	PMD transmit disable	1.9.1	PMD_transmit_disable_0
Restart training	BASE-R PMD control	1.150.0	mr_restart_training
Training enable	BASE-R PMD control	1.150.1	mr_training_enable
Polynomial identifier 3[a]	PMD training pattern lane 3	1.1453.12:11	identifier_3
Seed 3[a]	PMD training pattern lane 3	1.1453.10:0	seed_3
Polynomial identifier 2[a]	PMD training pattern lane 2	1.1452.12:11	identifier_2
Seed 2[a]	PMD training pattern lane 2	1.1452.10:0	seed_2
Polynomial identifier 1[b]	PMD training pattern lane 1	1.1451.12:11	identifier_1
Seed 1[b]	PMD training pattern lane 1	1.1451.10:0	seed_1
Polynomial identifier 0	PMD training pattern lane 3	1.1450.12:11	identifier_0
Seed 0	PMD training pattern lane 3	1.1450.10:0	seed_0
Initial condition request 3[a]	PMD training LP control lane 3	1.1123.13:12	ic_req (lane 3)
Coefficient select 3[a]	PMD training LP control lane 3	1.1123.4:2	coef_sel (lane 3)
Coefficient request 3[a]	PMD training LP control lane 3	1.1123.1:0	coef_req (lane 3)
Initial condition request 2[a]	PMD training LP control lane 2	1.1122.13:12	ic_req (lane 2)
Coefficient select 2[a]	PMD training LP control lane 2	1.1122.4:2	coef_sel (lane 2)
Coefficient request 2[a]	PMD training LP control lane 2	1.1122.1:0	coef_req (lane 2)
Initial condition request 1[b]	PMD training LP control lane 1	1.1121.13:12	ic_req (lane 1)
Coefficient select 1[b]	PMD training LP control lane 1	1.1121.4:2	coef_sel (lane 1)
Coefficient request 1[b]	PMD training LP control lane 1	1.1121.1:0	coef_req (lane 1)
Initial condition request 0	PMD training LP control lane 0	1.1120.13:12	ic_req (lane 0)
Coefficient select 0	PMD training LP control lane 0	1.1120.4:2	coef_sel (lane 0)
Coefficient request 0	PMD training LP control lane 0	1.1120.1:0	coef_req (lane 0)

[a]Available only in 200GBASE-CR4.
[b]Available only in 100GBASE-CR2 and 200GBASE-CR4.

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Table 136–6—MDIO/PMD status variable mapping

MDIO status variable	PMA/PMD register name	Register/bit number	PMD status variable
Fault	PMA/PMD status 1	1.1.7	PMD_fault
Transmit fault	PMA/PMD status 2	1.8.11	PMD_transmit_fault
Receive fault	PMA/PMD status 2	1.8.10	PMD_receive_fault
Global PMD receive signal detect	PMD receive signal detect	1.10.0	Global_PMD_signal_detect
PMD receive signal detect 3 to PMD receive signal detect 2[a]	PMD receive signal detect	1.10.4:3	PMD_signal_detect_3 to PMD_signal_detect_2
PMD receive signal detect 1[b]	PMD receive signal detect	1.10.2	PMD_signal_detect_1
PMD receive signal detect 0	PMD receive signal detect	1.10.1	PMD_signal_detect_0
Receiver status 3[a]	BASE-R PMD status	1.151.12	rx_trained_3
Frame lock 3[a]	BASE-R PMD status	1.151.13	local_frame_lock_3
Start-up protocol status 3[a]	BASE-R PMD status	1.151.14	training_3
Training failure 3[a]	BASE-R PMD status	1.151.15	training_failure_3
Receiver status 2[a]	BASE-R PMD status	1.151.8	rx_trained_2
Frame lock 2[a]	BASE-R PMD status	1.151.9	local_frame_lock_2
Start-up protocol status 2[a]	BASE-R PMD status	1.151.10	training_2
Training failure 2[a]	BASE-R PMD status	1.151.11	training_failure_2
Receiver status 1[b]	BASE-R PMD status	1.151.4	rx_trained_1
Frame lock 1[b]	BASE-R PMD status	1.151.5	local_frame_lock_1
Start-up protocol status 1[b]	BASE-R PMD status	1.151.6	training_1
Training failure 1[b]	BASE-R PMD status	1.151.7	training_failure_1
Receiver status 0	BASE-R PMD status	1.151.0	rx_trained_0
Frame lock 0	BASE-R PMD status	1.151.1	local_frame_lock_0
Start-up protocol status 0	BASE-R PMD status	1.151.2	training_0
Training failure 0	BASE-R PMD status	1.151.3	training_failure_0
Receiver ready 3[a]	PMD training LP status lane 3	1.1223.15	remote_rx_ready (lane 3)
Modulation and precoding status 3[a]	PMD training LP status lane 3	1.1223.11:10	tp_mode (lane 3)
Receiver frame lock 3[a]	PMD training LP status lane 3	1.1223.9	remote_tf_lock (lane 3)
Initial condition status 3[a]	PMD training LP status lane 3	1.1223.8	ic_sts (lane 3)
Coefficient status 3[a]	PMD training LP status lane 3	1.1223.2:0	coef_sts (lane 3)
Receiver ready 2[a]	PMD training LP status lane 2	1.1222.15	remote_rx_ready (lane 2)
Modulation and precoding status 2[a]	PMD training LP status lane 2	1.1222.11:10	tp_mode (lane 2)
Receiver frame lock 2[a]	PMD training LP status lane 2	1.1222.9	remote_tf_lock (lane 2)
Initial condition status 2[a]	PMD training LP status lane 2	1.1222.8	ic_sts (lane 2)

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Table 136–6—MDIO/PMD status variable mapping *(continued)*

MDIO status variable	PMA/PMD register name	Register/bit number	PMD status variable
Coefficient status 2[a]	PMD training LP status lane 2	1.1222.2:0	coef_sts (lane 2)
Receiver ready 1[b]	PMD training LP status lane 1	1.1221.15	remote_rx_ready (lane 1)
Modulation and precoding status 1[b]	PMD training LP status lane 1	1.1221.11:10	tp_mode (lane 1)
Receiver frame lock 1[b]	PMD training LP status lane 1	1.1221.9	remote_tf_lock (lane 1)
Initial condition status 1[b]	PMD training LP status lane 1	1.1221.8	ic_sts (lane 1)
Coefficient status 1[b]	PMD training LP status lane 1	1.1221.2:0	coef_sts (lane 1)
Receiver ready 0	PMD training LP status lane 0	1.1220.15	remote_rx_ready (lane 0)
Modulation and precoding status 0	PMD training LP status lane 0	1.1220.11:10	tp_mode (lane 0)
Receiver frame lock 0	PMD training LP status lane 0	1.1220.9	remote_tf_lock (lane 0)
Initial condition status 0	PMD training LP status lane 0	1.1220.8	ic_sts (lane 0)
Coefficient status 0	PMD training LP status lane 0	1.1220.2:0	coef_sts (lane 0)

[a]Available only in 200GBASE-CR4.
[b]Available only in 100GBASE-CR2 and 200GBASE-CR4.

136.8 PMD functional specifications

136.8.1 Link block diagram

One direction of a 50GBASE-CR, 100GBASE-CR2, or 200GBASE-CR4 link is shown in Figure 136–2.

Note that the source lane (SL) signals SL_i<p> and SL_i<n> are the positive and negative sides of the transmitter's differential signal pair on lane *i* and the destination lane (DL) signals DL_i<p> and DL_i<n> are the positive and negative sides of the receiver's differential signal pair on lane *i*.

For purposes of system conformance, the PMD sublayer is standardized at the test points described in this subclause.

The electrical transmit signal is defined at TP2. Unless specified otherwise, all transmitter measurements and tests defined in 136.9.3 are made at TP2 utilizing the test fixture specified in 136B.1.1.

The electrical receive signal is defined at TP3. Unless specified otherwise, all receiver measurements and tests defined in 136.9.4 are performed at TP3 utilizing the test fixture specified in 136B.1.1.

A mated connector pair has been included in both the transmitter and receiver specifications defined in 136.9.3 and 136.9.4. The recommended maximum insertion loss from TP0 to TP2 or TP3 to TP5 including the test fixture is provided in 92.8.3.6. Annex 136A provides information on parameters associated with test points TP0 and TP5 that may not be testable in an implemented system.

The channel (see 136.9) is defined between the transmitter (TP0) and receiver (TP5) blocks to include the transmitter and receiver differential controlled impedance printed circuit board insertion loss and the cable assembly insertion loss, as illustrated in Figure 136–2. All cable assembly measurements are to be made between TP1 and TP4 as illustrated in Figure 136–2. The cable assembly test fixture of 136B.1.1, or its

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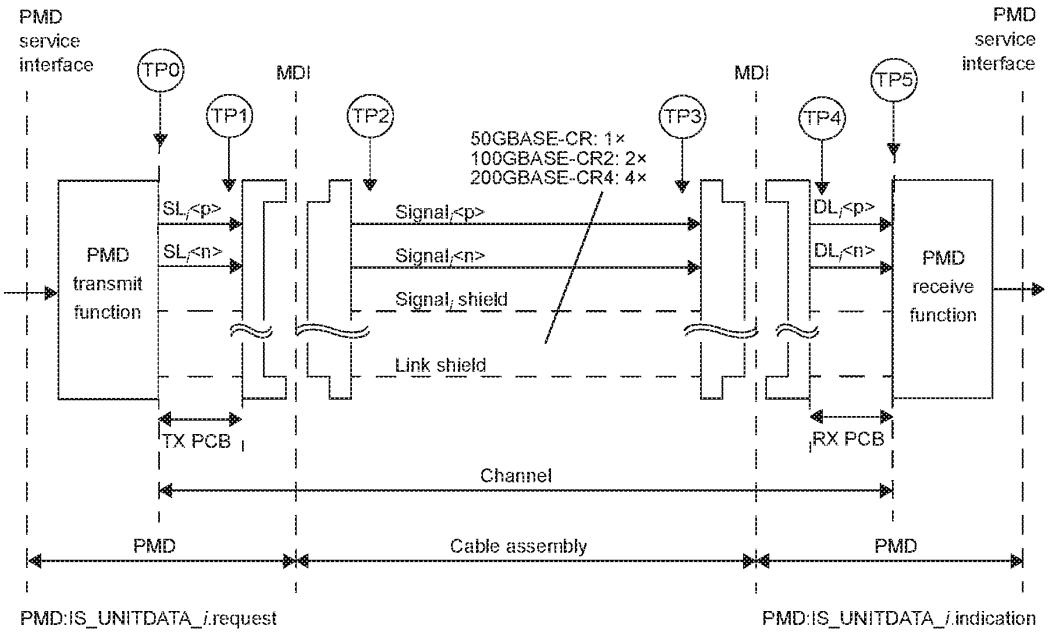


Figure 136–2—50GBASE-CR, 100GBASE-CR2 or 200GBASE-CR4 link (one direction is illustrated)

equivalent, is required for measuring the cable assembly specifications in 136.10 at TP1 and TP4. Two mated connector pairs and the cable assembly test fixture have been included in the cable assembly specifications defined in 136.10. Transmitter and receiver differential controlled impedance printed circuit board insertion losses defined between TP0 and the MDI and between the MDI and TP5, respectively, are provided informatively in 136A.4.

Table 136–7 describes the defined test points illustrated in Figure 136–2.

Table 136–7—Test points

Test points	Description
TP0 to TP5	The channel including the transmitter and receiver differential controlled impedance printed circuit board insertion loss and the cable assembly insertion loss.
TP1 to TP4	All cable assembly measurements are made between TP1 and TP4 as illustrated in Figure 136–2. The cable assembly test fixture of 136B.1.1, or its equivalent, is required for measuring the cable assembly specifications in 136.10 at TP1 and TP4.
TP0 to TP2 TP3 to TP5	A mated connector pair has been included in both the transmitter and receiver specifications defined in 136.9.3 and 136.9.4. The recommended maximum insertion loss from TP0 to TP2 or from TP3 to TP5 including the test fixture is provided in 92.8.3.6.
TP2	Unless specified otherwise, all transmitter measurements defined in 136.9.3 are made at TP2 utilizing the test fixture specified in 136B.1.1.
TP3	Unless specified otherwise, all receiver measurements and tests defined in 136.9.4 are made at TP3 utilizing the test fixture specified in 136B.1.1.

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136.8.2 PMD transmit function

The PMD transmit function has two operating modes, DATA and TRAINING. The operating mode is controlled by the PMD control state diagram (Figure 136–7).

When operating in DATA mode, the PMD transmit function shall convert the symbol stream requested by the PMD service interface message PMD:IS_UNITDATA_*i*.request(tx_symbol) of each lane into an electrical signal, and deliver the electrical signals to the MDI, according to the transmit electrical specifications in 136.9.3. The highest differential output voltage (SL_i<p> minus SL_i<n>) shall correspond to tx_symbol = three and the lowest differential output voltage shall correspond to tx_symbol = zero.

When operating in TRAINING mode, the PMD transmit function shall convert the symbol stream generated by the PMD control function of each lane into an electrical signal, and deliver the electrical signals to the MDI, according to the transmit electrical specifications in 136.9.3. The highest differential output voltage (SL_i<p> minus SL_i<n>) shall correspond to the symbol 3 and the lowest differential output voltage shall correspond to the symbol 0.

136.8.3 PMD receive function

The PMD receive function shall convert the electrical signal from each of the lanes on the MDI into a symbol stream for delivery to the PMD service interface using the messages PMD:IS_UNITDATA_*i*.indication(rx_symbol). The highest differential input voltage (DL_i<p> minus DL_i<n>) shall correspond to rx_symbol = three and the lowest differential input voltage shall correspond to rx_symbol = zero.

136.8.4 PMD global signal detect function

For the 50GBASE-CR PMD, the variable Global_PMD_signal_detect is set to PMD_signal_detect_0 (see 136.8.5). For the 100GBASE-CR2 and 200GBASE-CR4 PMDs, the variable Global_PMD_signal_detect is set to the logical AND of the values of PMD_signal_detect_*i* from each of the PMD lanes.

136.8.5 PMD lane-by-lane signal detect function

The PMD lane-by-lane signal detect function is used by the PMD to indicate the successful completion of the start-up protocol by the PMD control function (see 136.8.11). PMD_signal_detect_*i* shall be set to zero when signal_detect on lane *i* is set to false, and to one when signal_detect on lane *i* is set to true. The signal_detect variables are set independently on each lane by the PMD control state diagram (Figure 136–7).

If training is disabled by the management variable mr_training_enable (see 136.7), PMD_signal_detect_*i* shall be set to one for all lanes.

When the MDIO is implemented, this function maps the variables to registers and bits as defined in 136.7.

136.8.6 PMD global transmit disable function (optional)

The PMD global transmit disable function is optional. When implemented, it allows the transmitters on all lanes to be disabled with a single variable.

When Global_PMD_transmit_disable variable is set to one, this function shall turn off all the transmitters such that each transmitter drives a constant level (i.e., no transitions) and does not exceed the differential peak-to-peak output voltage (max.) with Tx disabled in Table 136–11.

If a PMD fault (136.8.8) is detected, then the PMD may set Global_PMD_transmit_disable to one.

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136.8.7 PMD lane-by-lane transmit disable function

The PMD lane-by-lane transmit disable function allows the transmitter in each lane to be selectively disabled.

When a PMD_transmit_disable_*i* variable is set to one, this function shall turn off the transmitter in lane *i* so that it drives a constant level (i.e., no transitions) and does not exceed the differential peak-to-peak output voltage (max.) with Tx disabled in Table 136–11.

If a PMD fault (136.8.8) is detected, then the PMD may set each PMD_transmit_disable_*i* to one, turning off the transmitter in each lane.

If MDIO is not implemented, an alternative method shall be provided to access the PMD_transmit_disable_*i* variables in order to enable independently disabling each transmit lane for testing purposes.

136.8.8 PMD fault function

PMD_fault is the logical-OR of PMD_receive_fault, PMD_transmit_fault, and any other implementation specific fault. If the MDIO interface is implemented, then PMD_fault shall be mapped to the fault bit as specified in 45.2.1.2.3.

136.8.9 PMD transmit fault function (optional)

The PMD transmit fault function is optional. The faults detected by this function are implementation specific, but the assertion of Global_PMD_transmit_disable is not considered a transmit fault.

If PMD_transmit_fault is set to one, then Global_PMD_transmit_disable should also be set to one.

If the MDIO interface is implemented, then PMD_transmit_fault shall be mapped to the Transmit fault bit as specified in 45.2.1.7.4.

136.8.10 PMD receive fault function (optional)

The PMD receive fault function is optional. The faults detected by this function are implementation specific. A fault is indicated by setting the variable PMD_receive_fault to one.

If the MDIO interface is implemented, then PMD_receive_fault shall be mapped to the Receive fault bit as specified in 45.2.1.7.5.

136.8.11 PMD control function

The PMD control function performs the PMD start-up protocol. This protocol facilitates timing recovery and equalization while providing a mechanism through which the receiver can configure the transmitter to optimize performance. The protocol supports these functions through the continuous exchange of fixed-length training frames.

The PMD shall implement one instance of the PMD control function described in this subclause for each lane. The PMD control functions operate independently on each lane.

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136.8.11.1 Training frame structure

The training frame is a sequence of PAM4 symbols whose values correspond to the possible values of the tx_symbol and rx_symbol variables (the symbol values 0, 1, 2, and 3 correspond to tx_symbol or rx_symbol values zero, one, two, and three, respectively). The structure of a training frame is shown in Figure 136–3.

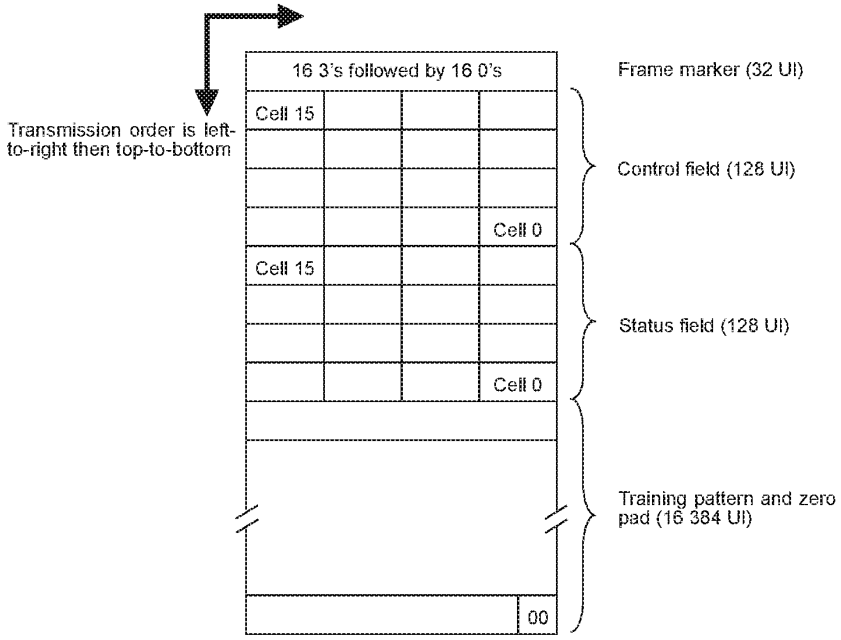


Figure 136–3—Training frame structure

136.8.11.1.1 Frame marker

Training frames are delimited by a specific sequence of PAM4 symbols. The training frame marker is a run of 16 consecutive "3" symbols followed by a run of 16 consecutive "0" symbols. This sequence is not found in the control field, status field, or training pattern and it uniquely identifies the beginning of a training frame.

136.8.11.1.2 Control and status fields

The control field comprises 16 bits with the structure defined in 136.8.11.2. The status field comprises 16 bits with the structure defined in 136.8.11.3.

Each bit of the control and status fields is sent as a differential Manchester encoded cell where each cell is eight unit intervals in length. The specific rules for this encoding follow.

a) A transition from 0 to 3 or from 3 to 0 occurs at the start of the cell.

b) A transition from 0 to 3 or from 3 to 0 at the midpoint of the cell, i.e., four unit intervals from the transition at the beginning of the cell, corresponds to a logical one.

c) The absence of a transition at the midpoint of the cell corresponds to a logical zero.

The control field is transmitted immediately after the frame marker where the first cell transmitted corresponds to the highest bit index in the field. The status field is transmitted immediately after the control field where the first cell transmitted corresponds to the highest bit index in the field.

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136.8.11.1.3 Training pattern

The training pattern is the result of a training pattern generator equivalent to the structure shown in Figure 136–4.

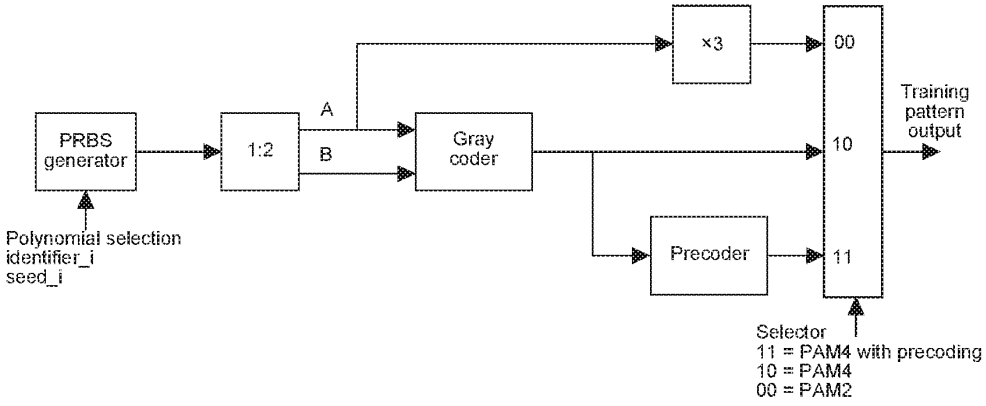


Figure 136–4—Training pattern generator

A set of four PRBS generator polynomials are defined to minimize correlated interference between PMDs, or physical lanes within a PMD, during the start-up protocol. The PRBS generator for each lane shall implement each of four generator polynomials defined in Table 136–8. The polynomial used in each lane i is selectable by identifier_i. The default identifier for each lane is its lane number (e.g., the default value for identifier_0 is 0 which selects polynomial_0). A sample implementation of the PRBS generator for identifier_i = 0 is shown in Figure 136–5.

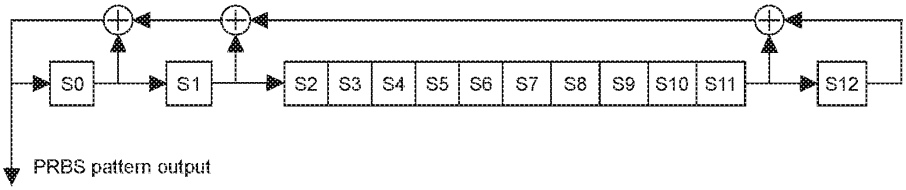


Figure 136–5—Training pattern PRBS generator (identifier_*i* = 0)

At the start of the training pattern, the state of the PRBS generator shall be set to the value seed_i. The default value of seed_i shall be the value given in Table 136–8 for $n = i$. A seed of all zeros is not valid.

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The polynomials for each identifier value n and the default seeds, as well as the first 13 symbols of the training pattern for each modulation and precoding mode, using the default seed, are provided in Table 136–8.

Table 136–8—Training patterns

n	Polynomial_n, $G(x)$	Default seed bits[a]	Initial output, PAM2	Initial output, PAM4	Initial output, PAM4 with precoding
0	$1 + x + x^2 + x^{12} + x^{13}$	0000010101011	0030330330000	1031320220111[b]	1301200200101
1	$1 + x^2 + x^3 + x^7 + x^{13}$	0011101000001	3030303030333	3030213021333	3122012201212
2	$1 + x^2 + x^4 + x^8 + x^{13}$	1001000101100	0303333033030	1212332133031	1102120121301
3	$1 + x^2 + x^5 + x^9 + x^{13}$	0100010000010	3330300030330	2231210121221	2032013201110

[a]The leftmost bit in the sequence corresponds to the initial value of S0 and the rightmost bit corresponds to the initial value of S12.
[b]This is equivalent to the PRBS13Q test pattern defined in 120.5.11.2.3.

For a given configuration of the PRBS generator, there are three possible training patterns. The construction of each training pattern begins by demultiplexing the PRBS generator output into pairs of bits {A, B} where A corresponds to the 1st, 3rd, 5th, etc. bits output by the PRBS generator and B corresponds to the 2nd, 4th, 6th, etc. bits output by the PRBS generator. There is a new pair of bits each unit interval which implies that the PRBS generator is required to generate bits at twice the signaling rate. Given these pairs of bits, the three different training patterns correspond to three modulation and precoding modes: PAM2, PAM4, PAM4 with precoding.

When the modulation and precoding mode is set to PAM2, the training pattern is the sequence of 16 382 PAM4 symbols derived by mapping only the A bits such that logical 0 is transmitted as 0 and logical 1 is transmitted as 3.

When the modulation and precoding mode is set to PAM4, the training pattern is the sequence of 16 382 PAM4 symbols derived by Gray coding the {A, B} pairs as specified in 135.5.7.1.

When the modulation and precoding mode is set to PAM4 with precoding, the training pattern is the sequence of 16 382 PAM4 symbols derived by Gray coding the {A, B} pairs as specified in 135.5.7.1 and precoding the result as specified in 135.5.7.2. The precoder state is initialized to 0 at the beginning of each training pattern, so that P(j=0) in Equation (135–1) is set to 0.

The modulation and precoding mode is set to PAM2 upon entry to the INITIALIZE state of the PMD control state diagram (see Figure 136–7).

NOTE—Exiting TRAINING mode requires both sides to use PAM4 modulation, thus the request and the status of the modulation and precoding are both required to have values other than PAM2 (either "PAM4" or "PAM4 with precoding").

136.8.11.1.4 Zero pad

Two "0" symbols are transmitted immediately after the training pattern. This zero pad ensures the training frame is DC balanced and helps to delineate the start of the frame marker for the next training frame.

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136.8.11.2 Control field structure

The structure of the control field shall be as shown in Table 136–9.

Table 136–9—Control field structure

Bit(s)	Name	Description
15:14	Reserved	Transmit as 0, ignore on receipt
13:12	Initial condition request	13 12 1 1 = Preset 3 1 0 = Preset 2 0 1 = Preset 1 0 0 = Individual coefficient control
11:10	Reserved	Transmit as 0, ignore on receipt
9:8	Modulation and precoding request	9 8 1 1 = PAM4 with precoding 1 0 = PAM4 0 1 = Reserved 0 0 = PAM2
7:5	Reserved	Transmit as 0, ignore on receipt
4:2	Coefficient select	4 3 2 1 1 0 = $c(-2)$ 1 1 1 = $c(-1)$ 0 0 0 = $c(0)$ 0 0 1 = $c(1)$
1:0	Coefficient request	1 0 1 1 = No equalization 1 0 = Decrement 0 1 = Increment 0 0 = Hold

136.8.11.2.1 Initial condition request

The initial condition request bits are used to select one of the three pre-defined transmitter equalizer configurations (presets) specified in 136.8.11.3.4. When the initial condition request bits are 00, the coefficient select and coefficient request bits are used to update the transmitter equalizer configuration.

136.8.11.2.2 Modulation and precoding request

The modulation and precoding request bits are used to request that the link partner transmitter transmit one of the three training pattern formats defined in 136.8.11.1.3.

136.8.11.2.3 Coefficient select

The coefficient select bits are used to identify the coefficient that is the target of a coefficient request. The value of the field is the two's complement encoding of the coefficient index. For example, binary value 111 corresponds to a coefficient index of –1.

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136.8.11.2.4 Coefficient request

The coefficient request bits are used to change the value of the coefficient specified by the coefficient select bits. A coefficient may be changed by incrementing or decrementing its value or by setting it to "No equalization". The "No equalization" value is 1 for $c(0)$ and 0 for $c(-2)$, $c(-1)$, and $c(1)$.

136.8.11.3 Status field structure

The structure of the status field is shown in Table 136–10.

Table 136–10—Status field structure

Bit(s)	Name	Description
15	Receiver ready	1 = Training is complete and the receiver is ready for data 0 = Request for training to continue
14:12	Reserved	Transmit as 0, ignore on receipt
11:10	Modulation and precoding status	11 10 1 1 = PAM4 with precoding 1 0 = PAM4 0 1 = Reserved 0 0 = PAM2
9	Receiver frame lock	1 = Frame boundaries identified 0 = Frame boundaries not identified
8	Initial condition status	1 = Updated 0 = Not updated
7	Parity	Even parity bit
6	Reserved	Transmit as 0, ignore on receipt
5:3	Coefficient select echo	5 4 3 1 1 0 = $c(-2)$ 1 1 1 = $c(-1)$ 0 0 0 = $c(0)$ 0 0 1 = $c(1)$
2:0	Coefficient status	2 1 0 1 1 1 = Reserved 1 1 0 = Coefficient at limit and equalization limit 1 0 1 = Reserved 1 0 0 = Equalization limit 0 1 1 = Coefficient not supported 0 1 0 = Coefficient at limit 0 0 1 = Updated 0 0 0 = Not updated

136.8.11.3.1 Receiver ready

The receiver ready bit is used to signal the local receiver state to the link partner. When this bit is 1, it indicates that the local receiver has completed training and is prepared to receive data. When this bit is 0, it indicates that the local receiver is requesting that training continue.

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136.8.11.3.2 Modulation and precoding status

The modulation and precoding status bits acknowledge the modulation and precoding request bits received from the link partner. When a change in the received modulation and precoding request bits are detected, the format of the training pattern is changed accordingly (see 136.8.11.1.3). The modulation and precoding status bits are then updated to confirm that the change to the format of the training pattern was completed.

136.8.11.3.3 Receiver frame lock

When the receiver frame lock bit is set to 1, the receiver is indicating that it has identified training frame marker positions and is in a state where the response time requirements specified in 136.8.11.6 are met.

Receiver frame lock shall be set to 0 upon entering TRAINING mode and shall not be set to 1 until local_tf_lock is true.

136.8.11.3.4 Initial condition status

The initial condition status bit acknowledges the initial condition request bits received from the link partner. The acknowledgment reflects the value of ic_sts resulting from the procedure described in 136.8.11.4.

136.8.11.3.5 Parity bit

The parity bit is calculated based on the other bits in the control field and status field to create even parity for these fields. Even parity ensures that the resulting pattern is DC balanced. This field may be ignored on receipt.

136.8.11.3.6 Coefficient select echo

The coefficient select echo bits acknowledge the coefficient select bits received from the link partner. When a change to the coefficient select bits is detected, the coefficient select echo bits are updated to represent the same coefficient index. This serves as a confirmation to the link partner that subsequent coefficient requests will act on the targeted coefficient.

136.8.11.3.7 Coefficient status

The coefficient status bits acknowledge the coefficient request bits received from the link partner. The acknowledge reflects the value of coef_sts resulting from the procedure described in 136.8.11.5.

136.8.11.4 Initial condition setting

When a change to the initial condition request bits is detected, the coefficients are configured in a manner consistent with the following algorithm.

```
if ic_req = ind_ctl
   ic_sts = not_upd
else
   if ic_req = preset 1
      Set coefficients to preset 1
   else if ic_req = preset 2
      Set coefficients to preset 2
   else if ic_req = preset 3
      Set coefficients to preset 3
   end if
   ic_sts = updated
end if
```

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The variables ic_req and ic_sts are defined in 136.8.11.7.1. The transmitter equalizer coefficients corresponding to each of the three presets shall be within the ranges specified in Table 136–12.

The transmitter equalizer is set to preset 1 upon entry to the INITIALIZE state of the PMD control state diagram.

136.8.11.5 Coefficient update

When a change to the coefficient select or coefficient request bits is detected, the corresponding coefficient update is performed in a manner consistent with the following algorithm.

```
if k in k_list

   if coef_req = INCREMENT
      ck_ask = c(k) + ck_stp
   else if coef_req = DECREMENT
      ck_ask = c(k) - ck_stp
   else if coef_req = NO_EQUALIZATION
      if k = 0
         ck_ask = 1
      else
         ck_ask = 0
      end if
   else
      ck_ask = c(k)
   end if

   if ck_ask > ck_max
      c(k) = ck_max
      if CHECK_EQ(ck_ask,k)
         coef_sts = COEFFICIENT AT LIMIT AND EQUALIZATION LIMIT
      else
         coef_sts = COEFFICIENT AT LIMIT
      end if
   else if ck_ask < ck_min
      c(k) = ck_min
      if CHECK_EQ(ck_ask,k)
         coef_sts = COEFFICIENT AT LIMIT AND EQUALIZATION LIMIT
      else
         coef_sts = COEFFICENT AT LIMIT
      end if
   else if CHECK_EQ(ck_ask,k)
      coef_sts = EQUALIZATION LIMIT
   else
      c(k) = ck_ask
      coef_sts = UPDATED
   end if
else
   coef_sts = COEFFICIENT NOT SUPPORTED
end if
```

The variables coef_req, coef_sts, and k are defined in 136.8.11.7.1. The following additional variables and functions are used.

c(k)

Variable that contains the current value of the coefficient *c*(k).

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ck_ask

Variable that contains the value of $c(k)$ that would result from the requested update.

ck_min

Variable that contains the minimum supported value of $c(k)$.

ck_max

Variable that contains the maximum supported value of $c(k)$.

ck_stp

Variable that contains the magnitude of the change in $c(k)$ for one step up or one step down from its current value.

k_list

The set of valid transmitter equalizer coefficient indices {–2, –1, 0, 1}.

CHECK_EQ(ck_ask,k)

Compares the transmitter's steady-state voltage that would result from setting transmit equalization coefficient $c(k)$ value to ck_ask, while keeping all other coefficients unchanged, against the transmitter's steady-state voltage (see 136.9.3.1.2) and equalization capability. Returns true if the resulting combination of coefficients would exceed the maximum steady-state voltage or the transmitter's equalization capability. Otherwise returns false.

136.8.11.6 Handshake timing

Changes to the configuration of the transmitter equalizer or the transmitted training pattern may occur at any point between the time the request for the new configuration is received and the time that the request is acknowledged.

The time from the receipt of a new request to the time that request is acknowledged shall be less than 2 ms when the receiver frame lock bit in the status field of transmitted training frames is set to 1. A new request is defined to be a received training frame whose control field differs from the control field of the preceding training frame. An acknowledgment is defined as the first transmitted training frame that contains a status field encoding that is an appropriate response for the requested action. For example, a change in the coefficient select bits in the control field would be acknowledged by a change in the coefficient select echo bits of the status field. Similarly, a change in the modulation and precoding request bits in the control field would be acknowledged by a change in the modulation and precoding status bits in the status field. All timing measurements are referred to a common reference point within the training frame (e.g., the 3 to 0 transition in the training frame marker).

The timing of requests and acknowledgment is illustrated in Figure 136–6.

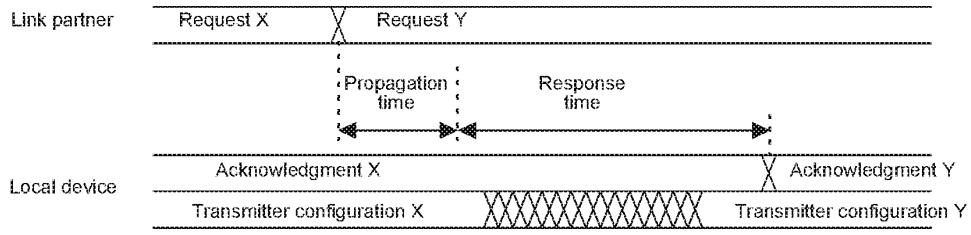


Figure 136–6—Transmitter update timing

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136.8.11.7 Variables, functions, timers, counters, and state diagrams

The PMD implements one instance of each of the PMD control state diagrams, and the set of associated variables, functions, counters and timers defined in this subclause, independently for each of the n physical lanes.

136.8.11.7.1 Variables

coef_req
: Enumerated variable derived from the "coefficient request" bits from the control field of the received training frames (see 136.8.11.2). This variable may be one of the following values: hold, decrement, increment, no equalization.

coef_sel
: Variable derived from the "coefficient select" bits from the control field of the received training frames (see 136.8.11.2). It is assigned a signed integer value that is the two's complement interpretation of the bits.

coef_sts
: Enumerated variable that may be assigned one of the following values (abbreviations used by the state diagram are included in parentheses): not updated (not_upd), updated, coefficient at limit, coefficient not supported. This value is assigned by the UPDATE_Cn function and encoded in the status field of transmitted training frames via the ENCODE_STS function.

ic_req
: Enumerated variable derived from the "initial condition request" bits from the control field of the received training frames (see 136.8.11.2). This variable may be assigned one of the following values (abbreviations used by the state diagram are included in parentheses): individual control (ind_ctl), preset 1, preset 2, preset 3.

ic_sts
: Enumerated variable that may be assigned one of the following values (abbreviations used by the state diagram are included in parentheses): not updated (not_upd), updated.

k
: Variable that stores the most recent value of coef_sel.

local_rx_ready
: Boolean variable that is set to true by the training state diagram when local_trained is asserted and is set to false otherwise. This value is encoded as the "receiver ready" bit in the status field of transmitted training frames.

local_tf_lock
: Boolean variable that is true if the value of training is true and training frame marker positions have been identified and is false otherwise.

local_trained
: Boolean variable that is set to true when the local receiver has determined that the remote transmit and local receive equalizers have been optimized and normal data transmission may commence. It is set to false otherwise. The exact criteria for setting this variable to true are implementation specific.

marker_valid
: Boolean variable that is set to true when the candidate frame marker matches the frame marker pattern defined in 136.8.11.1.1 and is set to false otherwise.

mr_restart_training
: Boolean variable used by system management to restart the start-up protocol. When set to true, it forces the PMD control state diagram to the INITIALIZE state.

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mr_training_enable
: Boolean variable used by system management to enable or disable the start-up protocol. When set to true it enables the start-up protocol, and when set to false it disables the start-up protocol.

new_marker
: Boolean variable that is set to true when a new candidate frame marker is available for testing and is set to false when the TEST_MARKER state is entered. A new frame marker is available for testing when the training frame lock process has accumulated 32 consecutive symbols starting at the candidate frame start position.

remote_rx_ready
: **Boolean variable derived from the "receiver ready"** bit of the status field of received training frames. If the bit is 1, the value of remote_rx_ready is true, otherwise it is false.

remote_tf_lock
: Boolean variable derived from **the "receiver frame lock" bit of** the status field of received training frames. If the bit is 1, the value of remote_tf_lock is true, otherwise it is false.

reset
: Boolean variable that resets the PMD. It is true whenever a reset is necessary including when reset is initiated from the MDIO, during power on, and when the MDIO has put the PMD into low-power mode. It is false otherwise.

signal_detect
: Boolean variable that is set to true when the training process is complete and is set to false otherwise. The value of signal_detect is used by the PMD lane-by-lane signal detect function (136.8.5).

slip_done
: Boolean variable that is set to TRUE when the SLIP requested by the Training frame lock state **diagram (Figure 136–8) is completed indicating** that the next candidate frame sync position can be tested.

tf_offset
: Boolean variable that is set to true when receiving one full training frame (16 672 symbols, see 136.8.11.1) following the recent frame start position, such that a new frame marker is expected. Otherwise it is set to false

tp_mode
: Enumerated variable that **corresponds to the "modulation and precoding status" bits in the** status field of received training frames. It may be assigned one of the following values: pam2, pam4, pam4 with precoding.

training
: Boolean variable that is set to true when the start-up protocol is in progress and is set to false otherwise.

training_failure
: Boolean variable that is set to true when training failed to complete successfully within the allotted time limit. Otherwise it is set to false.

136.8.11.7.2 Functions

ENCODE_STS
: Encodes portions of the status field of transmitted training frames. local_tf_lock is mapped to the receiver frame lock bit, k is mapped to the coefficient select echo bits, coef_sts is mapped to the coefficient status bits, ic_sts is mapped to the initial condition status bit, local_rx_ready is mapped to the receiver ready bit, and tp_mode is mapped to modulation and precoding bits (see 136.8.11.3.2).

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SLIP

Causes the next candidate frame marker position to be tested. Repeated invocations of SLIP cause all possible positions to be evaluated. The precise method for determining the next candidate frame marker position is implementation dependent and beyond the scope of this standard.

TRANSMIT(tx_mode)

Controls the output of the PMD transmit function on the current lane. When tx_mode = DATA, the PMD transmit function output is the parameter of the PMD:IS_UNITDATA_*i*.request primitive (see 136.3). When tx_mode = TRAINING, the PMD transmit function output is the stream of symbols generated by the PMD control function.

UPDATE_Cn

Updates the value of $c(k)$ based on the current values of the variables k and coef_req. The result of the update is stored in the variable coef_sts. This function implements the algorithm specified in 136.8.11.5.

UPDATE_IC

Updates all transmit equalizer coefficients based on the current value of the variable ic_req. The result is stored in the variable ic_sts. This function implements the algorithm specified in 136.8.11.3.4.

136.8.11.7.3 Timers

holdoff_timer

This timer is started when the PMD control state diagram enters the TIMEOUT state. The terminal count of holdoff_timer is 80 ms ± 2%.

max_wait_timer

This timer sets the limit for how long the PMD start-up protocol is allowed to operate. It is started upon entry to the INITIALIZE state of the PMD control state diagram. If the timer expires before the LINK_READY state is reached, then a failure to train is indicated. The terminal count of max_wait_timer is 1.5 s ± 2%.

wait_timer

This timer is started when the local receiver has completed training and detects that the remote receiver is ready to receive data. The local transmitter sends additional training frames until the timer expires to ensure that the link partner correctly detects the local receiver state. The terminal count of wait_timer is between 25 µs and 125 µs, equivalent to approximately 40 to 200 training frames.

136.8.11.7.4 Counters

bad_markers

Count of the number of consecutive frame marker mismatches.

good_markers

Count of the number of consecutive frame marker matches.

136.8.11.7.5 State diagrams

The notation used in the state diagrams follows the conventions of 21.5. State diagram timers follow the conventions of 14.2.3.2. The notation ++ after a counter indicates that its value is to be incremented.

The PMD control state diagram (Figure 136–7) defines the operation of the start-up protocol.

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If the LINK_READY state is entered while the modulation and precoding status bits indicate "PAM4 with precoding", then the PMD shall cause the adjacent PMA to transmit all subsequent data on the corresponding lane with precoding (see 135.5.7.2 and 120.5.7.2).

If the LINK_READY state is entered while the modulation and precoding request bits are set to "PAM4 with precoding", then the PMD shall inform the adjacent PMA that all subsequently received data on the corresponding lane includes precoding (see 135.5.7.2 and 120.5.7.2).

The PMD control state diagram is supported by the training frame lock and coefficient update state diagrams. The training frame lock state diagram (Figure 136–8) determines when the PMD control function has detected training frame boundaries. The coefficient update state diagram (Figure 136–9) defines the process for updating the local transmitter equalizer coefficients in response to requests from the link partner.

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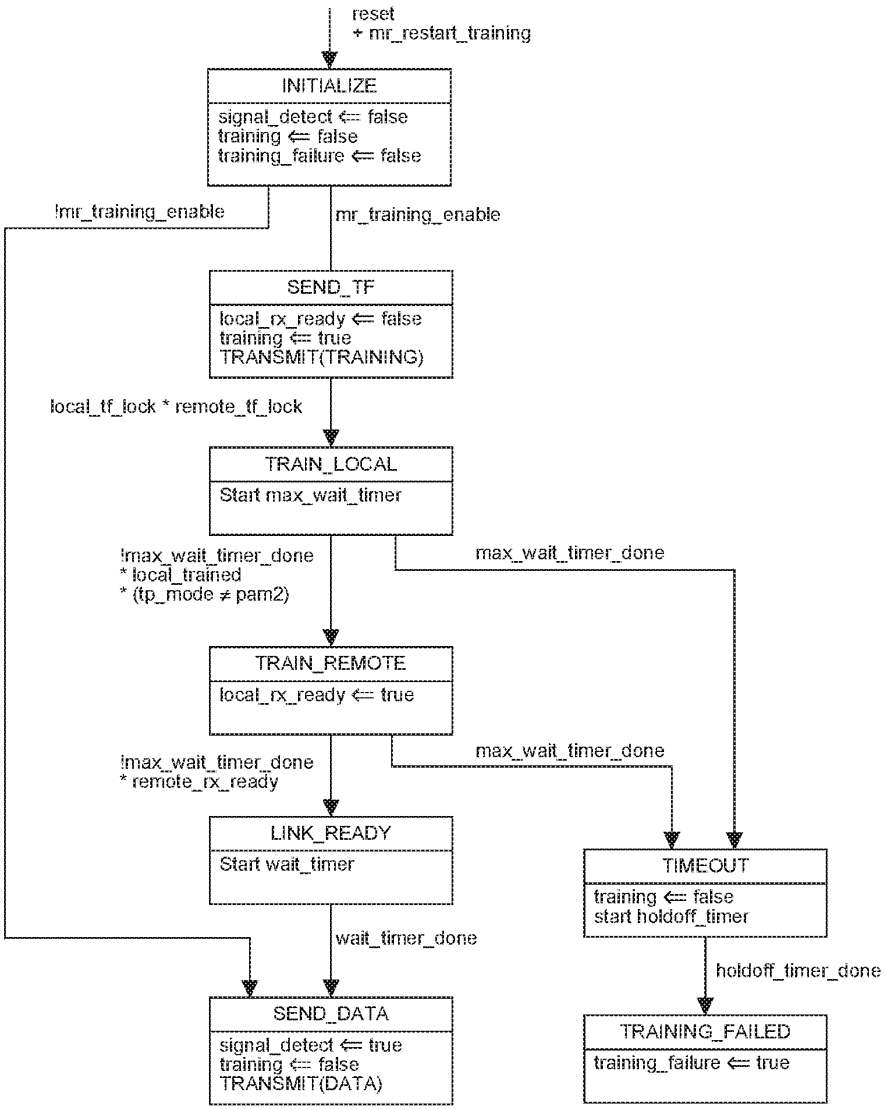


Figure 136–7—PMD control state diagram

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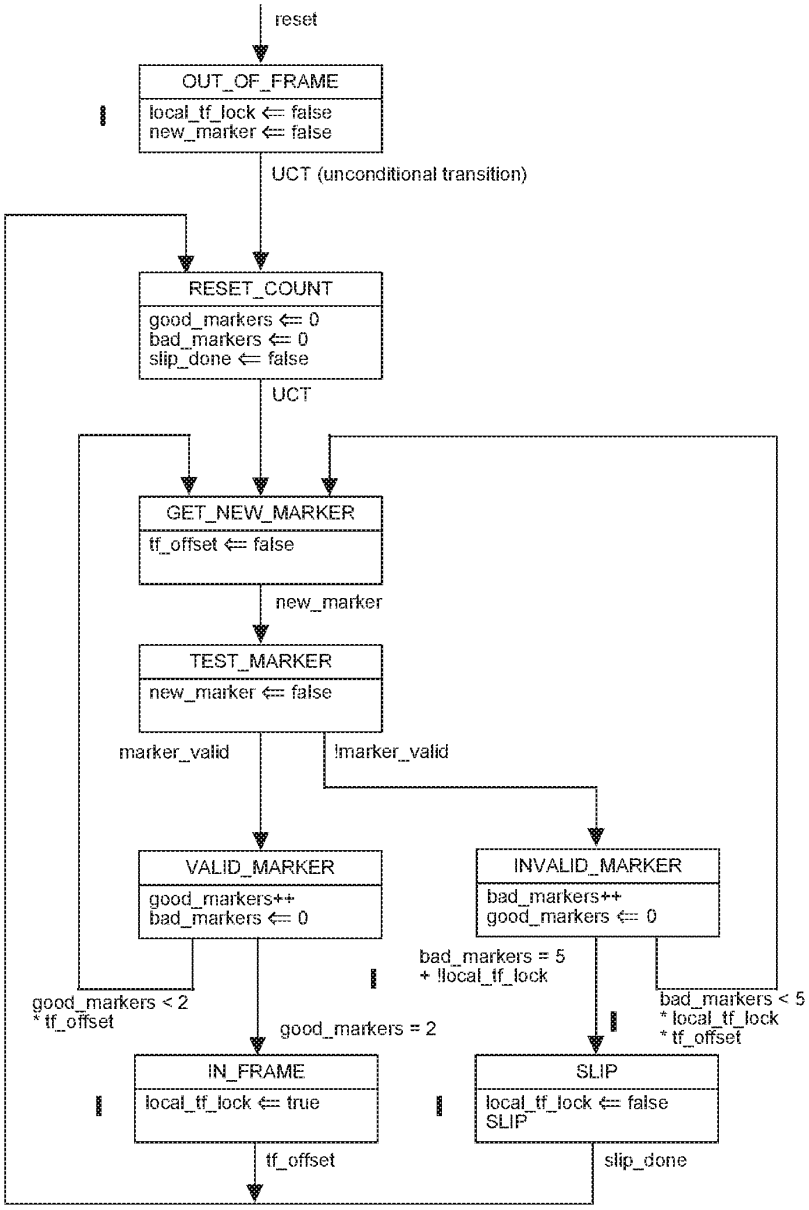


Figure 136–8—Training frame lock state diagram

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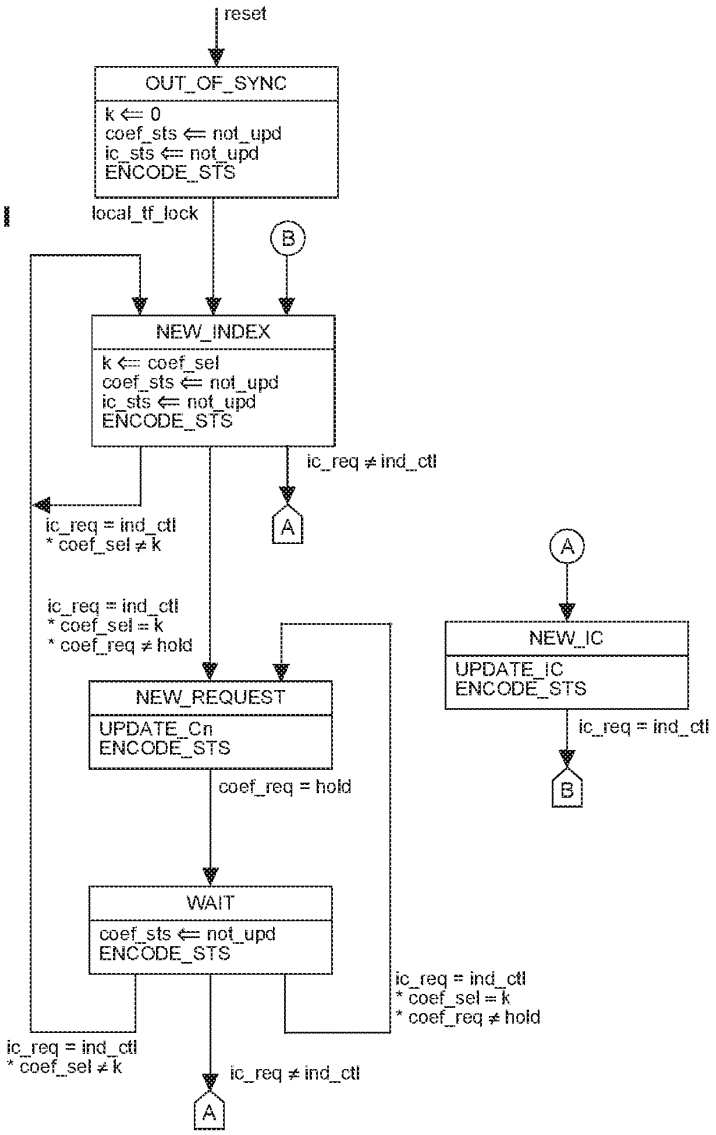


Figure 136–9—Coefficient update state diagram

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136.9 Electrical characteristics

136.9.1 AC-coupling

The MDI (see 136.12) is a low-swing AC-coupled differential interface. AC-coupling within the plug connectors, as defined in 136.12, allows for interoperability between components operating from different supply voltages.

136.9.2 Signal paths

The MDI transmit and receive paths are point-to-point connections. Each path corresponds to one MDI lane and comprises two complementary signals, which form a balanced differential pair.

For 50GBASE-CR, there is one differential path in each direction for a total of two pairs, or four connections. For 100GBASE-CR2, there are two differential paths in each direction for a total of four pairs, or eight connections. For 200GBASE-CR4, there are four differential paths in each direction for a total of eight pairs, or sixteen connections.

136.9.3 Transmitter characteristics

The transmitter on each lane shall meet the specifications given in **Table 136–11 and detailed in the** referenced subclauses. Unless specified otherwise, all transmitter measurements are made for each lane separately, at TP2, utilizing the test fixtures specified in 136B.1.1, using a test system with a fourth-order Bessel-Thomson low-pass response with 33 GHz 3 dB bandwidth.

The transmitter characteristics at TP0 are provided informatively in 136A.2.

Table 136–11—Summary of transmitter specifications at TP2

Parameter	Subclause reference	Value	Units
Differential pk-pk output voltage (max.) with Tx disabled[a]	94.3.12.3	30	mV
DC common-mode voltage (max.)[a]	94.3.12.3	1.9	V
AC common-mode RMS output voltage, v_{cmi} (max.)[a]	94.3.12.3	30	mV
Differential pk-pk voltage, v_{di} (max.)[a]	94.3.12.3	1.200	mV
Differential output return loss (min.)	92.8.3.2	See Equation (92–1)	dB
Common-mode to differential mode output return loss (min.)	92.8.3.3	See Equation (92–2)	dB
Common-mode to common-mode output return loss (min.)	92.8.3.4	See Equation (92–3)	dB
Transmitter steady-state voltage, v_f (min.) Transmitter steady-state voltage, v_f (max.)	136.9.3.1.2	0.34 0.6	V
Linear fit pulse peak (min.)	136.9.3.1.2	$0.49 \times v_f$	V
Level separation mismatch ratio R_{LM} (min.)	120D.3.1.2.1	TBD	----

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Table 136–11—Summary of transmitter specifications at TP2

Parameter	Subclause reference	Value	Units
Transmitter output waveform			
abs step size for $c(-1)$, $c(0)$, and $c(1)$ (min.)	136.9.3.1.4	0.005	—
abs step size for $c(-1)$, $c(0)$, and $c(1)$ (max.)	136.9.3.1.4	0.05	—
abs step size for $c(-2)$ (min.)	136.9.3.1.4	0.005	—
abs step size for $c(-2)$ (max.)	136.9.3.1.4	0.025	—
value at minimum state for $c(-1)$ and $c(1)$ (max.)	136.9.3.1.5	−0.25	—
value at maximum state for $c(-2)$ (min.)	136.9.3.1.5	0.1	—
Signal-to-noise-and-distortion ratio (min.)	TBD	TBD	dB
SNR_{ISI} (min.)	120D.3.1.7	30	dB
Output jitter (max.)	120D.3.1.1		
Even-odd jitter, pk-pk		0.019	UI
J_{RMS}		TBD	UI
J4		TBD	UI
Signaling rate		26.5625 ± 100 ppm	GBd
Unit interval nominal		37.64706	ps

[a]Measurement uses the method described in 94.3.12.3 with the exception that the PRBS13Q test pattern is used.

136.9.3.1 Transmitter output waveform

The transmit function includes programmable equalization to compensate for the frequency-dependent loss of the channel and facilitate data recovery at the receiver. The functional model for the transmit equalizer on each lane is the four-tap transversal filter shown in Figure 136–10.

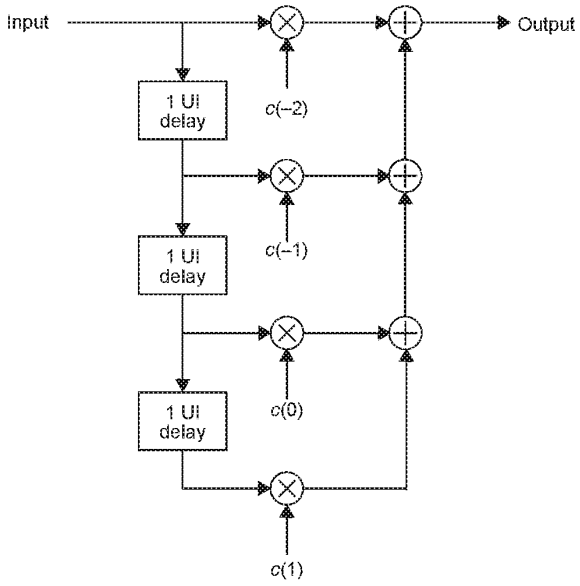


Figure 136–10—Transmit equalizer functional model

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The state of the transmit equalizer and hence the transmitted output waveform may be manipulated via the PMD control function defined in 136.8.11 or via the management interface. The transmit function responds to a set of commands issued by the link partner's receive function and conveyed by a back-channel communications path. This command set includes instructions to increment, decrement, hold, or set to zero a selected coefficient $c(k)$, where k = –2 to 1. In addition, it includes commands to set all coefficients to one of three initial conditions.

In response, the transmit function relays status information to the link partner's receive function. The status messages indicate the selected coefficient index k, the status of the coefficient $c(k)$ (updated, not updated, or at limit), and the status of the initial condition (updated or not updated).

136.9.3.1.1 Linear fit to the measured waveform

The following procedure is used to determine the linear fit pulse response, linear fit error, and normalized transmitter coefficient values.

Set the transmitter under test to transmit the PRBS13Q test pattern (defined in 120.5.11.2.1). For each configuration of the transmit equalizer, capture at least one complete cycle of the test pattern at TP2, as specified in 85.8.3.3.4. The clock recovery unit (CRU) used in the measurement has a corner frequency of 4 MHz and a slope of 20 dB/decade.

In the following calculations, M should be an integer not less than 32. Interpolation of the captured waveform may be used to achieve this.

Compute the linear fit pulse response $p(k)$, k=1 to $M \times N_p$, from the captured waveform, as specified in 85.8.3.3.5, with N_p = 200 and D_p = 3, where the aligned symbols $x(n)$ are assigned normalized amplitudes –1, –*ES*, *ES*, and 1 to represent the PAM4 symbol values 0, 1, 2, and 3 respectively. *ES* is defined as $(|ES1| + |ES2|)/2$ where *ES1* and *ES2* are calculated according to 120D.3.1.2.

Define $r(k)$ to be the linear fit pulse response when transmit equalizer coefficients have been set to the "pre-set 1" values. The normalized coefficients for any configuration of the transmit equalizer are computed using the following method.

For each value of m in the range $-M/2$ to $M/2-1$ when M is even and $-(M-1)/2$ to $(M-1)/2$ when M is odd:

a) Define an $M \times N_p$-by-4 matrix R_m. The elements of R_m are assigned values per Equation (136–1) where i = –2 to 1 and j = 1 to $M \times N_p$.

$$R_m(j, i+3) = \begin{cases} r(m) + j - M \times i & \text{if } 1 \le m + j - M \times i \le M \times N_p \\ 0 & \text{otherwise} \end{cases} \quad (136\text{–}1)$$

b) The normalized coefficients of the transmit equalizer are computed using Equation (136–2).

$$\begin{bmatrix} c_m(-2) \\ c_m(-1) \\ c_m(0) \\ c_m(1) \end{bmatrix} = (R_m^T R_m)^{-1} R_m^T \begin{bmatrix} p(1) \\ \dots \\ p(M \times N_p) \end{bmatrix} \quad (136\text{–}2)$$

c) The linear fit pulse response is reconstructed from the matrix R_m and the normalized coefficients using Equation (136–3).

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$$\begin{bmatrix} p_m(1) \\ \cdots \\ p_m(M \times N_p) \end{bmatrix} = R_m \begin{bmatrix} c_m(-2) \\ c_m(-1) \\ c_m(0) \\ c_m(1) \end{bmatrix} \quad (136\text{–}3)$$

d) $\varepsilon^2(m)$ is computed using Equation (136–4).

$$\varepsilon^2(m) = \sum_{k=1}^{M \times N_p} (p(k) - p_m(k))^2 \quad (136\text{–}4)$$

The normalized transmit equalizer coefficients $c(i)$ for a given linear fit pulse $p(k)$ are the values $c_m(i)$ for the value of m that minimizes $\varepsilon^2(m)$.

136.9.3.1.2 Steady-state voltage and linear fit pulse peak

The steady-state voltage v_f is defined to be the sum of the linear fit pulse $p(k)$ divided by M (refer to 85.8.3.3 step 3). The steady-state voltage shall be greater than or equal to 0.34 V and less than or equal to 0.6 V after the transmit equalizer initial condition has been set to preset 1 (no equalization).

The peak value of $p(k)$ shall be greater than $0.49 \times v_f$ after the transmit equalizer initial condition has been set to preset 1 (no equalization).

Editor's note: the baseline proposal is based on clause 92, which specifies the peak-to-v_f ratio minimum as 0.45. This specification was changed to 0.49 in clause 110 due to consideration of transition time in 802.3by. The editor considers the latter value to be more adequate here.

136.9.3.1.3 Coefficient initialization

When the Coefficient update state diagram (Figure 136–9) is in either the OUT_OF_SYNC state or the NEW_IC state, the coefficients of the transmit equalizer shall be configured to values within the ranges specified in Table 136–12 (according to the value of the variable ic_req). These requirements apply upon the assertion of Initial condition status of "Updated".

Table 136–12—Coefficient initial conditions

Coefficient update state	ic_req	$c(-2)$	$c(-1)$	$c(0)$	$c(1)$
OUT_OF_SYNC	N/A	0 ± 0.025	0 ± 0.05	1 ± 0.05	0 ± 0.05
NEW_IC	preset 1	0 ± 0.025	0 ± 0.05	1 ± 0.05	0 ± 0.05
	preset 2	0 ± 0.025	0 ± 0.05	0.75 ± 0.05	–0.25 ± 0.05
	preset 3	0 ± 0.025	–0.25 ± 0.05	0.75 ± 0.05	0 ± 0.05

136.9.3.1.4 Coefficient step size

When coef_sel is –1, 0, or 1, the change in the normalized transmit equalizer coefficient c(coef_sel) corresponding to a request to "increment" shall be between 0.005 and 0.05, and the change in the normalized

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transmit equalizer coefficient c(coef_sel) corresponding to a request to "decrement" shall be between –0.05 and –0.005.

When coef_sel is –2, the change in the normalized transmit equalizer coefficient $c(-2)$ corresponding to a request to "increment" shall be between 0.005 and 0.025, and the change in the normalized transmit equalizer coefficient c(coef_sel) corresponding to a request to "decrement" shall be between –0.025 and –0.005.

The change in the normalized transmit equalizer coefficient is defined to be the difference in the value measured prior to the assertion of the "increment" or "decrement" request (i.e., coef_req is "Hold") and the value upon the assertion of a coefficient status of "updated".

136.9.3.1.5 Coefficient range

When sufficient "increment" or "decrement" requests have been received for a given coefficient, the coefficient reaches a lower or upper bound based on the range of that coefficient or the combination of coefficients.

With $c(-2)$ and $c(-1)$ both set to zero and both $c(0)$ and $c(1)$ having received sufficient "decrement" requests so that they are at their respective minimum values, $c(1)$ shall be less than or equal to –0.25.

With $c(-2)$ and $c(1)$ set to zero and both $c(-1)$ and $c(0)$ having received sufficient "decrement" requests so that they are at their respective minimum values, $c(-1)$ shall be less than or equal to –0.25.

With $c(-1)$ and $c(1)$ set to zero, $c(0)$ having received sufficient "decrement" requests so that it is at its minimum value, and $c(-2)$ having received sufficient "increment" requests so that it is at its maximum value, $c(-2)$ shall be greater than or equal to 0.1.

NOTE—a coefficient may be set to zero by asserting a coefficient request of "no equalization" for that coefficient, using the control function specified in 136.8.11, or by implementation specific means.

136.9.4 Receiver characteristics

Receiver electrical characteristics are specified at TP3. The receiver shall meet the return loss requirements specified in 92.8.4.2 and 92.8.4.3. In addition, the requirements in 136.9.4.1, 136.9.4.2, 136.9.4.3 and 136.9.4.4 apply.

The receiver specifications at TP5 are provided informatively in 136A.3.

136.9.4.1 Receiver input amplitude tolerance

When a PMD receiver is connected to a compliant transmitter whose peak-to-peak differential output voltage (see Table 136–11 footnote a) measured at the preset 1 equalizer setting is 1 200 mV, using a compliant cable assembly with the minimum insertion loss specified in 136.11.2, the PMD receiver shall operate at a BER better than 10^{-4}.

Editor's note (to be removed after draft 1.2): The response to comment #146 against draft 1.1 was to replace the reference for peak-to-peak differential output voltage from 92.8.3.1 to 136.9.3. Since 136.9.3 is a general transmitter characteristics subclause, the editor judged that the specific reference to Table 136–11 footnote a would be preferable in this case, and hence the implementation differs from the resolved comment.

The receiver is allowed to control the transmitter equalizer coefficients, using the PMD control function defined in 136.8.11 or an equivalent process, to meet these requirements.

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134. Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 50GBASE-R PHYs

134.1 Overview

134.1.1 Scope

This clause specifies a Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 50GBASE-R PHYs.

The RS-FEC sublayer for 50GBASE-R PHYs is identical to the RS-FEC sublayer for 100GBASE-R PHYs specified in Clause 91 with the following exceptions:

1) The service interface has four PCS lanes instead of 20 PCS lanes
2) It only implements the RS(544,514) Reed-Solomon encoder option defined in 91.5.2.7.
3) The output of the Reed-Solomon encoder is distributed to two FEC lanes, rather than the four FEC lanes described in 91.5.2.8.
4) The alignment marker processing is modified to account for the difference in the alignment marker format between the 50GBASE-R PCS (Clause 133) and the 100GBASE-R PCS (Clause 82), for the fact that the alignment markers are mapped to two FEC lanes rather than four FEC lanes, and for the fact that the alignment marker mapping to the two FEC lanes needs to maintain a 10-bit alignment.
5) The definition of some of the variables and counters for the state diagrams in 91.5.4 are modified to support the different alignment marker spacing and the different number of FEC lanes
6) The states identified as optional in the FEC synchronization state diagram in 91.5.4.3 **(Figure 91–8)** are mandatory for the 50GBASE-R RS-FEC.
7) The optional EEE deep sleep capability is not supported.
8) The optional FEC bypass correction feature is not supported.

134.1.2 Position of RS-FEC in the 50GBASE-R sublayers

Figure 134–1 shows the relationship of the RS-FEC sublayer to the ISO/IEC Open System Interconnection (OSI) reference model.

134.2 FEC service interface

This subclause specifies the services provided by the RS-FEC sublayer. The service interface is described in an abstract manner and does not imply any particular implementation.

The FEC service interface is provided to allow the PCS to transfer information to and from the RS-FEC. The PCS may be connected to the RS-FEC using an optional instantiation of the PMA service interface (see Annex 135B) in which case a PMA is the client of the FEC service interface.

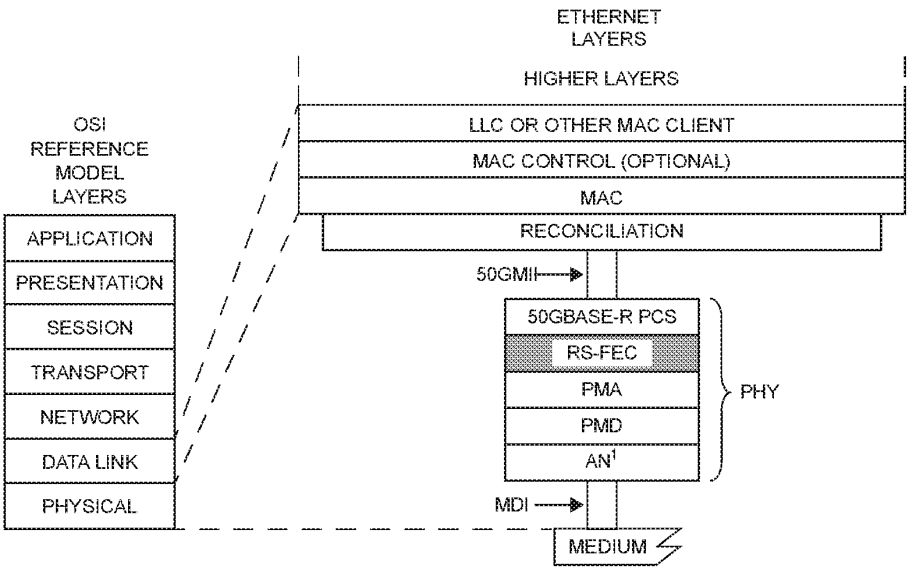
The FEC service interface is an instance of the inter-sublayer service interface defined in 131.3. The FEC service interface primitives are summarized as follows:

FEC:IS_UNITDATA_*i*.request
FEC:IS_UNITDATA_*i*.indication
FEC:IS_SIGNAL.indication

The RS-FEC operates on four parallel bit streams, hence $i = 0$ to 3.

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50GMII = 50 Gb/s MEDIA INDEPENDENT INTERFACE
AN = AUTO-NEGOTATION
LLC = LOGICAL LINK CONTROL
MAC = MEDIA ACCESS CONTROL
MDI = MEDIUM DEPENDENT INTERFACE
PCS = PHYSICAL CODING SUBLAYER
PHY = PHYSICAL LAYER DEVICE
PMA = PHYSICAL MEDIUM ATTACHMENT
PMD = PHYSICAL MEDIUM DEPENDENT
RS-FEC = REED-SOLOMON FORWARD ERROR CORRECTION

NOTE 1—CONDITIONAL BASED ON PHY TYPE

Figure 134–1—RS-FEC relationship to the ISO/IEC Open Systems Interconnection (OSI) reference model and the IEEE 802.3 Ethernet model

The PCS or PMA continuously sends four parallel bit streams to the RS-FEC, one per PCS lane, each at a nominal signaling rate of 12.890625 Gb/s. The RS-FEC continuously sends four parallel bit streams to the PCS or PMA, one per PCS lane, each at a nominal signaling rate of 12.890625 Gb/s.

The SIGNAL_OK parameter of the FEC:IS_SIGNAL.indication primitive can take one of two values: OK or FAIL. The value is set to OK when the FEC receive function has identified codeword boundaries as indicated by fec_align_status equal to true. That value is set to FAIL when the FEC receive function is unable to reliably establish codeword boundaries as indicated by fec_align_status equal to false. When SIGNAL_OK is FAIL, the rx_bit parameters of the FEC:IS_UNITDATA_*i*.indication primitives are undefined.

134.3 PMA compatibility

The RS-FEC sublayer requires that the PMA service interface consist of exactly two upstream FEC lanes and exactly two downstream FEC lanes, with each lane running at a nominal signaling rate of 26.5625 Gb/s. Therefore, the RS-FEC sublayer may be a client of the 50GBASE-R PMA sublayer defined in Clause 135, when the PMA service interface width, *p*, is set to 2.

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134.4 Delay constraints

The maximum delay contributed by the RS-FEC sublayer (sum of transmit and receive delays at one end of the link) shall be no more than 25 600 bit times (50 pause_quanta or 512 ns). A description of overall system delay constraints and the definitions for bit times and pause_quanta can be found in 131.4 and its references.

134.5 Functions within the RS-FEC sublayer

134.5.1 Functional block diagram

A functional block diagram of the RS-FEC sublayer is shown in Figure 134–2.

134.5.2 Transmit function

134.5.2.1 PCS Lane block synchronization

The RS-FEC transmit function forms four bit streams by concatenating the bits from each of the four FEC:IS_UNITDATA_*i*.request primitives in the order they are received. It obtains lock to the 66-bit blocks in each bit stream using the sync headers and outputs 66-bit blocks. Block lock is obtained as specified in the block lock state diagram shown in Figure 82–12, but using the variable definitions from 133.2.4.

134.5.2.2 PCS Alignment lock and deskew

Once the RS-FEC transmit function achieves block lock on a PCS lane, it then begins obtaining alignment marker lock as specified by the alignment marker lock state diagram shown in Figure 82–13, but using the variable definitions from 133.2.4. This process identifies the PCS lane number received on a particular lane of the service interface. After alignment marker lock is achieved on all four PCS lanes, all inter-lane Skew is removed as specified by the PCS deskew state diagram shown in Figure 82–14, but using the variable definitions from 133.2.4. The RS-FEC transmit function shall support a maximum Skew of 49 ns and a maximum Skew Variation of 0.4 ns. Skew and Skew Variation are defined in 131.5.

134.5.2.3 PCS Lane reorder

PCS lanes can be received on different lanes of the service interface from which they were originally transmitted due to Skew between lanes and multiplexing by the PMA. The RS-FEC transmit function shall order the PCS lanes according to the PCS lane number.

134.5.2.4 Alignment marker removal

After all PCS lanes are aligned and deskewed, the PCS lanes are multiplexed together in the proper order to reconstruct the original stream of blocks and the alignment markers are removed from the data stream. Note that an alignment marker is always removed when am_lock is true for a given PCS lane even if it does not match the expected alignment marker value (due to a bit error for example). Repeated alignment marker errors result in am_lock being set to false for a given PCS lane, but until that happens it is sufficient to remove the block in the alignment marker position.

As part of the alignment marker removal process, the BIP_3 field is compared to the calculated Bit Interleaved Parity (BIP) value (see 82.2.8) for each PCS lane. If a Clause 45 MDIO is implemented, then the appropriate BIP error counter register (registers 1.230 to 1.233) is incremented by one each time the calculated BIP value does not equal the value received in the BIP_3 field. The incoming bit error ratio can be estimated by dividing the BIP block error ratio by a factor of 1 351 680.

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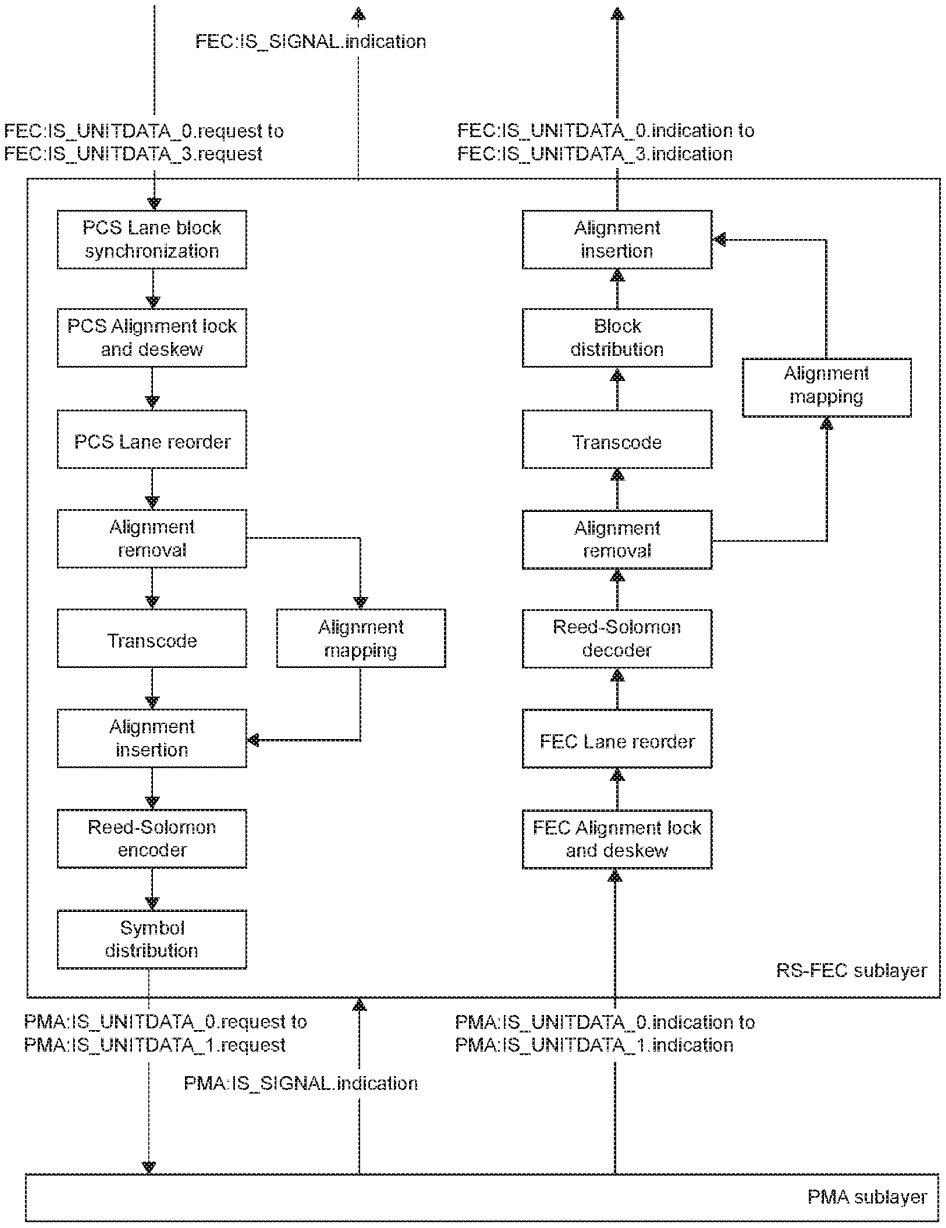


Figure 134–2—Functional block diagram

134.5.2.5 64B/66B to 256B/257B transcoder

The 64B/66B to 256B/257B transcoder is identical to the transcoder for the 100GBASE-R RS-FEC sublayer defined in 91.5.2.5.

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134.5.2.6 Alignment marker mapping and insertion

The alignment markers that were removed per 134.5.2.4 are re-inserted after being processed by the alignment marker mapping function. The alignment marker mapping function compensates for the operation of the symbol distribution function defined in 134.5.2.8 and rearranges the alignment marker bits so that they appear on the FEC lanes intact and in the desired sequence. This preserves the properties of the alignment markers (e.g., DC balance, transition density) and provides a deterministic pattern for the purpose of synchronization at the receiver. The RS-FEC receive function uses knowledge of this mapping to determine the FEC lane that is received on a given lane of the PMA service interface, to compensate for skew between FEC lanes, and to identify RS-FEC codeword boundaries.

The alignment marker mapping function operates on a group of four aligned and reordered alignment markers received from the PCS. Let am_tx_*x*<65:0> be the alignment marker for PCS lane *x*, *x*=0 to 3, where bit 0 is the first bit transmitted. The alignment markers shall be mapped to am_txmapped<256:0> in a manner that yields the same result as the following process.

For *x*=0 to 3, amp_tx_*x*<63:0> is constructed as follows:

- Set $y = 0$ when $x \leq 1$, otherwise set $y = x$.
- amp_tx_*x*<23:0> is set to M_0, M_1, and M_2 as shown in Figure 82–9 (bits 25 to 2) using the values in Table 82–3 for PCS lane number *y*.
- amp_tx_*x*<31:24> = am_tx_*x*<33:26>
- amp_tx_*x*<55:32> is set to M_4, M_5, and M_6 as shown in Figure 82–9 (bits 57 to 34) using the values in Table 82–3 for PCS lane number *y*.
- amp_tx_*x*<63:56> = am_tx_*x*<65:58>

This process replaces the fixed bytes of the alignment markers received from the PCS, possibly with errors, with the values from Table 82–3. In addition it substitutes the fixed bytes of the alignment markers corresponding to PCS lane 1 with the fixed bytes for the alignment marker corresponding to PCS lane 0. The variable bytes of the alignment markers received from the PCS (BIP_3 and BIP_7) are unchanged. This simplifies the synchronization process at the RS-FEC receiver, as the receiver only needs to search for the fixed alignment marker bytes corresponding to PCS lane 0 on each FEC lane.

am_txpayloads<0,129:0> and am_txpayloads<1,125:0> are then constructed from amp_tx as follows:

- am_txpayloads<0, 63:0> = amp_tx_0<63:0>
- am_txpayloads<0, 127:64> = amp_tx_2<63:0>
- am_txpayloads<0, 129:128> = amp_tx_3<57:56>
- am_txpayloads<1, 63:0> = amp_tx_1<63:0>
- am_txpayloads<1, 119:64> = amp_tx_3<55:0>
- am_txpayloads<1, 125:120> = amp_tx_3<63:58>

This process is an intermediate step in the generation of am_txmapped<256:0>, and is illustrated in Figure 134–3.

Given *i*=0 to 1, *k*=0 to 12, and *y*=*i*+2*k*, am_txmapped<255:0> is constructed from am_txpayloads as follows:

- If (*y* < 25) then am_txmapped<(10*y*+9):10*y*> = am_txpayloads<*i*, (10*k*+9):10*k*>
- am_txmapped<255:250> = am_txpayloads<1, 125:120>

A 1-bit pad is appended to the mapped alignment markers to yield the equivalent of one 257-bit block. The pad bit, am_txmapped<256>, shall be set to 0 or 1 in an alternating pattern.

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am_txmapped<256:0> is inserted into the data path prior to the Reed-Solomon encoder (see Figure 134–4) every 4 × 20 480 66-bit blocks, corresponding to every 1 024 Reed-Solomon codewords. The mapped alignment markers, am_txmapped<256:0> shall be inserted as the first 257 message bits to be transmitted every 1024th codeword. The first 257-bit block inserted after am_txmapped shall correspond to the four 66-bit blocks received on PCS lanes 0, 1, 2, and 3 that immediately followed the alignment marker on each respective PCS lane.

The result of this alignment mapping process is that after Reed-Solomon encoding and symbol distribution (134.5.2.7 and 134.5.2.8 respectively), the alignment marker bit patterns shown in Figure 134–3 appear on the two FEC output lanes and aligned with the start of every 1024th FEC codeword. The FEC receiver uses this information to lock onto the two FEC lanes and to identify the FEC codeword boundaries.

An additional result of this alignment mapping process, is that the BIP_3 and BIP_7 fields from normal PCS alignment markers are carried across the link protected by FEC. These fields cannot be used to monitor errors on the link protected by FEC as 64B/66B to 256B/257B transcoding and Reed-Solomon encoding alters the bit sequence. However, these fields may again be used to monitor errors after the original bit sequence is restored, i.e., following Reed-Solomon decoding and 256B/257B to 64B/66B transcoding.

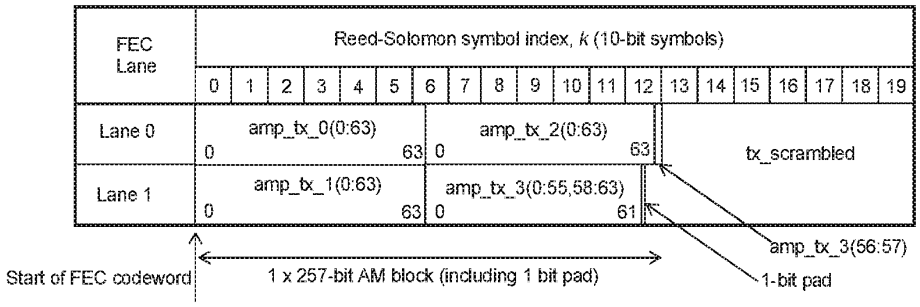


Figure 134–3—Alignment marker mapping to FEC lanes

134.5.2.7 Reed-Solomon encoder

The Reed-Solomon encoder is identical to the RS(544,514) Reed-Solomon encoder defined in 91.5.2.7.

134.5.2.8 Symbol distribution

Once the data has been Reed-Solomon encoded, it is distributed to two FEC lanes, one 10-bit symbol at a time in a round robin distribution from the lowest to the highest numbered FEC lane. The distribution process is shown in Figure 134–4.

134.5.2.9 Transmit bit ordering

The transmit bit ordering is illustrated in Figure 134–4.

134.5.3 Receive function

134.5.3.1 Alignment lock and deskew

The RS-FEC receive function forms two bit streams by concatenating the bits from each of the two PMA:IS_UNITDATA_*i*.indication primitives in the order they are received. It obtains lock to the alignment markers as specified by the FEC synchronization state diagram shown in Figure 91–8, but using the variable definitions from 134.5.4.

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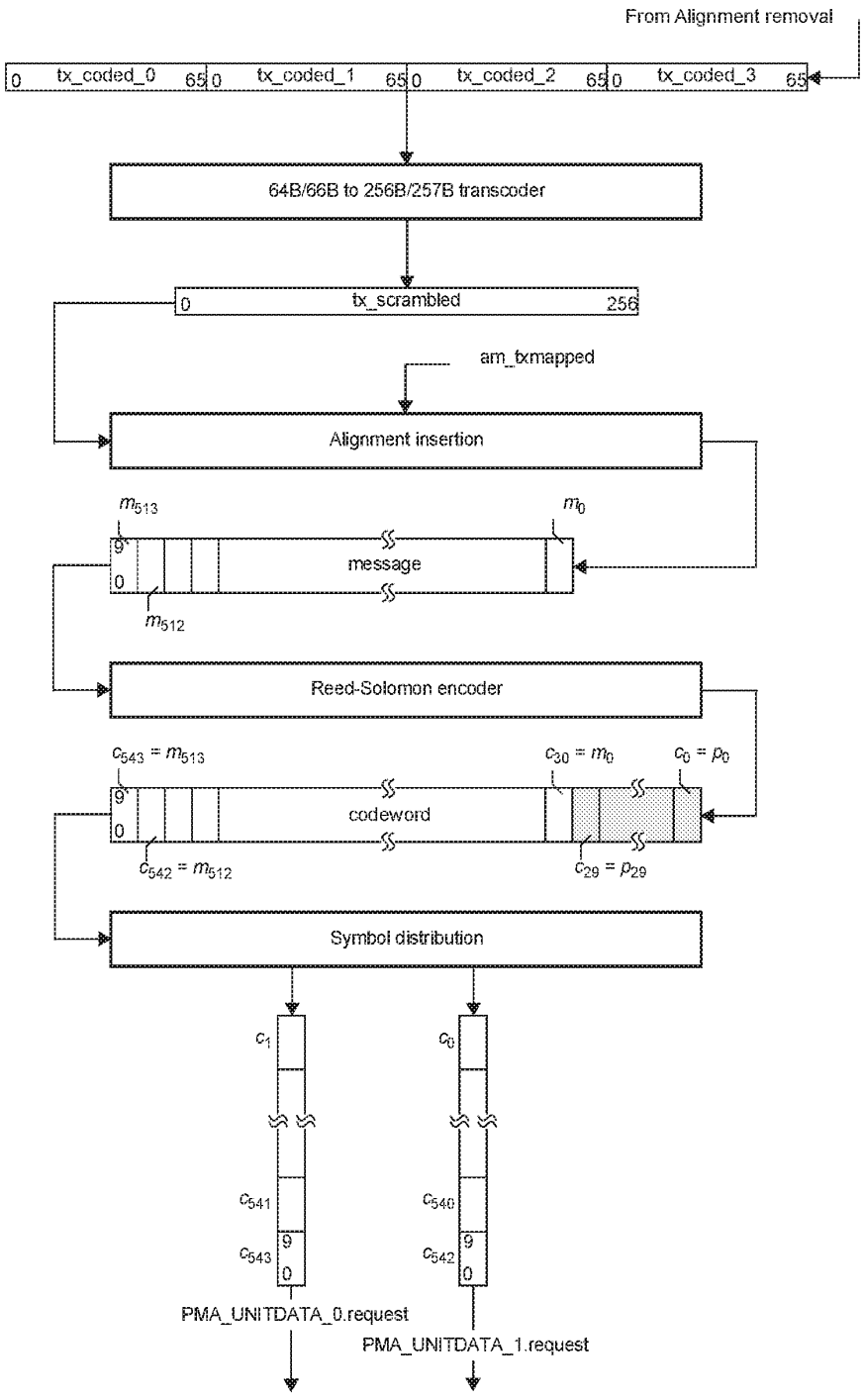


Figure 134–4—Transmit bit ordering

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After alignment marker lock is achieved the two FEC lanes, all inter-lane Skew is removed as specified by the FEC alignment state diagram shown in Figure 91–9. The FEC receive function shall support a maximum Skew of 180 ns between FEC lanes and a maximum Skew Variation of 4 ns.

134.5.3.2 FEC Lane reorder

FEC lanes can be received on different lanes of the service interface from which they were originally transmitted. The FEC receive function shall order the FEC lanes according to the FEC lane number (see 134.5.2.6). The FEC lane number is defined by the sequence of alignment markers that are mapped to each FEC lane.

After all FEC lanes are aligned, deskewed, and reordered, the FEC lanes are multiplexed together in the proper order to reconstruct the original stream of FEC codewords.

134.5.3.3 Reed-Solomon decoder

The Reed-Solomon decoder extracts the message symbols from the codeword, corrects them as necessary, and discards the parity symbols.

The RS-FEC sublayer shall be capable of correcting any combination of up to t=15 symbol errors in a codeword. The RS-FEC sublayer shall also be capable of indicating when an errored codeword was not corrected. The probability that the decoder fails to indicate a codeword with t+1 errors as uncorrected is not expected to exceed 10^{-6}. This limit is also expected to apply for t+2 errors, t+3 errors, and so on.

The Reed-Solomon decoder shall indicate errors to the PCS sublayer by intentionally corrupting 66-bit block synchronization headers. When the decoder determines that a codeword contains errors that were not corrected, it ensures that for every other 257-bit block within the codeword starting with the first (1st, 3rd, 5th, etc.), the synchronization header for the first 66-bit block at the output of the 256B/257B to 64B/66B transcoder, rx_coded_0<1:0>, is set to 11. In addition, it shall ensure that rx_coded_0<1:0> corresponding to the second 257-bit block and rx_coded_3<1:0> corresponding to the last (20th) 257-bit block in the codeword are set to 11. Setting rx_coded_0<1:0> to 11 as described causes the PCS to assign R_BLOCK_TYPE=E to the 66-bit block and decode its content as EBLOCK_R (see 49.2.13.2.1 and 49.2.13.2.3). This causes the PCS to discard all frames 64 bytes and larger that are fully or partially contained within the codeword.

The Reed-Solomon decoder may optionally provide the ability to bypass the error indication feature to reduce the delay contributed by the RS-FEC sublayer. The presence of this option is indicated by the assertion of the FEC_bypass_indication_ability variable (see 134.6.2). When the option is provided it is enabled by the assertion of the FEC_bypass_indication_enable variable (see 134.6.1).

When FEC_bypass_indication_enable is asserted, additional error monitoring is performed by the RS-FEC sublayer to reduce the likelihood that errors in a packet are not detected. The Reed-Solomon decoder counts the number of symbol errors detected in consecutive non-overlapping blocks of 8192 codewords. When the number of symbol errors in a block of 8192 codewords exceeds 6380, the Reed- Solomon decoder shall cause synchronization header rx_coded<1:0> of each subsequent 66-bit block that is delivered to the PCS to be assigned a value of 00 or 11 for a period of 60 ms to 75 ms. As a result, the PCS sets hi_ber = true, which inhibits the processing of received packets. When Auto-Negotiation is supported and enabled, assertion of hi_ber causes Auto-Negotiation to restart.

134.5.3.4 Alignment marker removal

The first 257 message bits in every 1024th codeword is the vector am_rxmapped<256:0> where bit 0 is the first bit received. The specific codewords that include this vector are indicated by the alignment lock and deskew function (see 134.5.3.1).

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The vector am_rxmapped shall be removed prior to transcoding.

134.5.3.5 256B/257B to 64B/66B transcoder

The 256B/257B to 64B/66B transcoder is identical to the transcoder for the 100GBASE-R RS-FEC sublayer defined in 91.5.3.5.

134.5.3.6 Block distribution

After the data has been transcoded, it shall be distributed to four PCS lanes, one 66-bit block at a time in a round robin distribution from the lowest to the highest numbered PCS lanes. The distribution process is shown in Figure 82–6.

134.5.3.7 Alignment marker mapping and insertion

The alignment marker mapping function compensates for operation of the lane reorder function (see 134.5.2.3) to derive the PCS lane alignment markers, am_rx_*x*<65:0> for *x*=0 to 3, from am_rx-mapped<256:0> (see134.5.3.4).

The alignment markers shall be derived from am_rxmapped<256:0> in a manner that yields the same result as the following process.

Given *i*=0 to 1, *k*=0 to 12, and *y*=*i*+2*k*, am_rxpayloads is constructed from am_rxmapped as follows:.

— If (*y* < 25) then am_rxpayloads<*i*, (10*k*+9):10*k*> = am_rxmapped<(10*y*+9):10*y*>

— am_rxpayloads<1, 125:120> = am_rxmapped<255:250>

The one bit pad am_rxmapped<256> is ignored by the receiver.

For *x*=0 to 3, amp_rx_*x*<63:0> is constructed from am_rxpayloads as follows:

— amp_rx_0<63:0> = am_rxpayloads<0, 63:0>

— amp_rx_1<63:0> = am_rxpayloads<1, 63:0>

— amp_rx_2<63:0> = am_rxpayloads<0, 127:64>

— amp_rx_3<55:0> = am_rxpayloads<1, 119:64>

— amp_rx_3<57:56> = am_rxpayloads<0, 129:128>

— amp_rx_3<63:58> = am_rxpayloads<1, 125:120

For *x*=0 to 3, am_rx_*x*<65:0> is constructed as follows:

— am_rx_*x*<0>=1 and am_rx_*x*<1>=0.

— am_rx_*x*<25:2> is set to M_0, M_1, and M_2 as shown in Figure 82–9 using the values in Table 82–3 for PCS lane number *x*.

— am_rx_*x*<33:26> = amp_rx_*x*<31:24>.

— am_rx_*x*<57:34> is set to M_4, M_5, and M_6 as shown in Figure 82–9 using the values in Table 82–3 for PCS lane number *x*.

— am_rx_*x*<65:58> = amp_rx_*x*<63:56>

One vector is mapped to four alignment markers every 1 024 Reed-Solomon codewords (see 134.5.3.4). The alignment markers are simultaneously transmitted on the four PCS lanes after every 20 479th column of four 66-bit blocks.

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The alignment markers am_rx_0 to am_rx_3 shall be inserted so that they are immediately followed by rx_coded_0 to rx_coded_3, respectively, as derived from the first 257-bit block following am_rxmapped

134.5.3.8 Receive bit ordering

The receive bit ordering is illustrated in Figure 134–5. This illustration shows the case where the FEC lanes appear across the PMA:IS_UNITDATA_*i*.indication primitives in the correct order.

134.5.4 Detailed functions and state diagrams.

The state diagrams, including the associated definitions of variables, functions and counters, are identical to those for the 100GBASE-R RS-FEC sublayer defined in 91.5.4, with the exception that some of the variables and counters are redefined to account for the differences in alignment marker spacing and number of FEC lanes.

In addition, EEE optional deep sleep capability is not supported for 50GBASE-R PHYs and therefore any reference to the optional EEE deep sleep capability in 91.5.4 can be ignored.

134.5.4.1 State diagram conventions

The state diagram conventions are identical to those defined in 91.5.4.1.

134.5.4.2 State variables

134.5.4.2.1 Variables

This following variables are redefined from what is described in 91.5.4.2.1:

amp_valid
: Boolean variable that is set to true if the received 64-bit block is a valid alignment marker payload. The alignment marker payload, mapped to an FEC lane according to the process described in 134.5.2.6, consists of 48 known bits and 16 variable bits (the BIP3 field and its complement BIP7 see 82.2.7). The bits of the candidate block that are in the positions of the known bits in the alignment marker payload are compared on a nibble-wise basis (12 comparisons). If no more than 3 nibbles in the candidate block fail to match the corresponding known nibbles in the alignment marker payload, the candidate block is considered a valid alignment marker payload. Each FEC lane compares the candidate block to the alignment marker payload for PCS lane 0.

amps_lock<*x*>
: Boolean variable that is set to true when the receiver has detected the location of the alignment marker payload sequence for a given lane on the PMA service interface, where *x* = 0:1.

fec_lane
: A variable that holds the FEC lane number (0 to 1) received on lane *x* of the PMA service interface when amps_lock<*x*> = true. The FEC lane number is determined by the alignment marker payloads in the 2nd position of the sequence based on the mapping defined in 134.5.2.6. The 48 bits that are in the positions of the known bits in the received alignment marker payload are compared to the expected values for a given payload position and FEC lane on a nibble-wise basis (12 comparisons). If no more than 3 nibbles in the candidate block fail to match the corresponding known nibbles on a given FEC lane, then the FEC lane number is assigned accordingly.

fec_lpi_fw
: Boolean variable that controls the behavior of the Transmit LPI and Receive LPI state dia-

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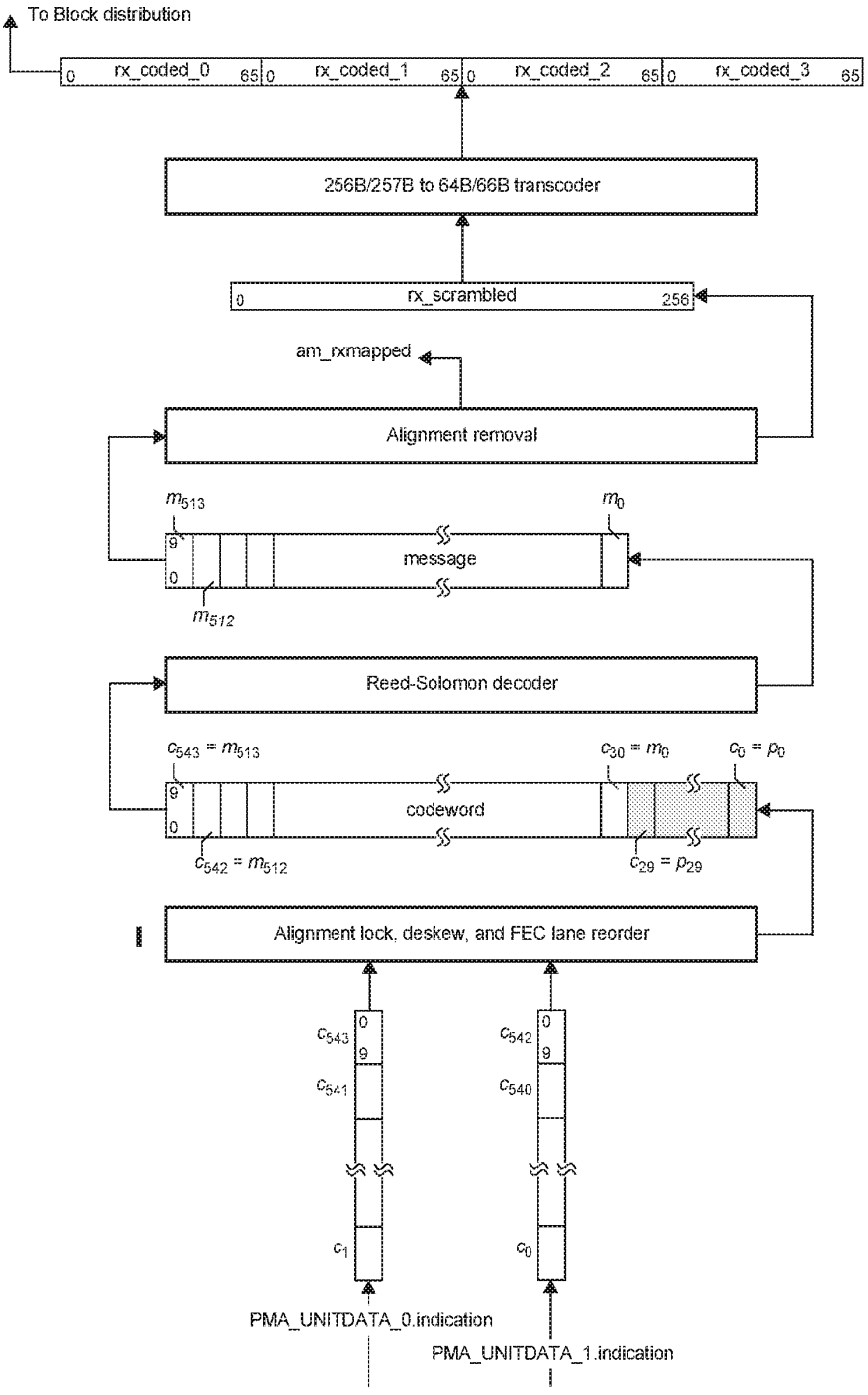


Figure 134–5—Receive bit ordering

grams. This variable is set to true when the local PCS is configured to use the fast wake mechanism and set to false otherwise. This variable shall always be set to true.

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fec_optional_states

Boolean variable that is always set to true to indicate that the optional states in the FEC synchronization state diagram in Figure 91–8 are implemented.

134.5.4.2.2 Functions

The functions are identical to those defined in 91.5.4.2.2.

134.5.4.2.3 Counters

This following counters are redefined from what is described in 91.5.4.2.3:

amp_counter

This counter counts the 1 024 FEC codewords that separate the ends of two consecutive normal alignment marker payload sequences. A FEC codeword is 2 720 bits per FEC lane

134.5.4.3 State diagrams

The state diagrams are identical to those defined in 91.5.4.3.

134.6 RS-FEC MDIO function mapping

The optional MDIO capability described in Clause 45 defines several registers that provide control and status information for and about the RS-FEC. If MDIO is implemented, it shall map MDIO control bits to RS-FEC control variables as shown in Table 134–1, and MDIO status bits to RS-FEC status variables as shown in Table 134–2, and if a separated PMA (see 45.2.1) is connected to the FEC service interface (e.g., if the RS-FEC and PCS are separated via a LAUI-2 interface) it shall map additional MDIO status bits to additional RS-FEC status variables as shown in Table 134–3.

Table 134–1—MDIO/RS-FEC control variable mapping

MDIO control variable	PMA/PMD register name	Register/bit number	FEC variable
FEC bypass indication enable	RS-FEC control register	1.200.1	FEC_bypass_indication_enable

The following subclauses define variables that are not otherwise defined, e.g., for use by state diagrams.

134.6.1 FEC_bypass_indication_enable

This variable is set to one to bypass the error indication function (see 91.5.3.3) when this ability is supported. When this variable is set to zero, the decoder indicates errors to the PCS sublayer. The default value of this variable is zero. This variable is mapped to the bit defined in 45.2.1.101 (1.200.1).

134.6.2 FEC_bypass_indication_ability

The Reed-Solomon decoder may have the option to bypass the error indication function (see 91.5.3.3) to reduce the delay contributed by the RS-FEC sublayer. This variable is set to one to indicate that the decoder has the ability to bypass error indication. The variable is set to zero if this ability is not supported. This variable is mapped to the bit defined in 45.2.1.102 (1.201.1).

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Table 134–2—MDIO/RS-FEC status variable mapping

MDIO control variable	PMA/PMD register name	Register/bit number	FEC variable
FEC bypass indication ability	RS-FEC status register	1.201.1	FEC_bypass_indication_ability
RS-FEC high SER	RS-FEC status register	1.201.2	hi_ser
FEC AM lock *x*, *x*=0 to 1	RS-FEC status register	1.201.8:9	amps_lock<*x*>
RS-FEC align status	RS-FEC status register	1.201.14	fec_align_status
FEC corrected codewords	RS-FEC corrected code-words counter register	1.202, 1.203	FEC_corrected_cw_counter
FEC uncorrected codewords	RS-FEC uncorrected code-words counter register	1.204, 1.205	FEC_uncorrected_cw_counter
FEC lane *x* mapping	RS-FEC lane mapping register	1.206	FEC_lane_mapping<*x*>
FEC symbol errors, FEC lanes 0 to 1	RS-FEC symbol error counter register, FEC lanes 0 to 1	1.210 to 1.213	FEC_symbol_error_counter_*i*

Table 134–3—MDIO/RS-FEC status variable mapping for separated PMA

MDIO control variable	PMA/PMD register name	Register/bit number	FEC variable
PCS align status	RS-FEC status register	1.201.15	align_status
BIP errors, PCS lanes 0 to 3	RS-FEC BIP error counter register, PCS lanes 0 to 3	1.230 to 1.233	BIP_error_counter_*i*
PCS lane *x* mapping	PCS lane *x* mapping register	1.250 to 1.253	lane_mapping<*x*>
Block *x* lock	RS-FEC PCS alignment status 1 register	1.280	block_lock<*x*>
Lane *x* aligned	RS-FEC PCS alignment status 3 register	1.282	am_lock<*x*>

134.6.3 hi_ser

This variable is defined when the FEC_bypass_indication_ability variable is set to one. When FEC_bypass_indication_enable is set to one, this bit is set to one if the number of RS-FEC symbol errors in a window of 8 192 codewords exceeds the threshold (see 91.5.3.3) and is set to zero otherwise. This variable is mapped to the bit defined in 45.2.1.102 (1.201.2).

134.6.4 amps_lock<*x*>

These variables are assigned by the FEC alignment state diagram shown in Figure 91–9 (see 91.5.4.3 and 134.5.4). They are mapped to the bits defined in 45.2.1.102 (1.201.8 to 1.201.9 for FEC lanes 0 to 1, respectively).

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134.6.5 fec_align_status

This variable assigned by the FEC alignment state diagram shown in Figure 91–9 (see 91.5.4.3). It is mapped to the bit defined in 45.2.1.102 (1.201.14).

134.6.6 FEC_corrected_cw_counter

A corrected FEC codeword is a codeword that contains errors and was corrected.

FEC_corrected_cw_counter is a 32-bit counter that counts once for each corrected FEC codeword processed when fec_align_status is true. This variable is mapped to the registers defined in 45.2.1.103 (1.202, 1.203).

134.6.7 FEC_uncorrected_cw_counter

An uncorrected FEC codeword is a codeword that contains errors (when the bypass correction feature is supported and enabled) or contains errors that were not corrected (when the bypass correction feature is not supported or not enabled).

FEC_uncorrected_cw_counter is a 32-bit counter that counts once for each uncorrected FEC codeword processed when fec_align_status is true. This variable is mapped to the registers defined in 45.2.1.104 (1.204, 1.205).

134.6.8 FEC_lane_mapping<*x*>

When the RS-FEC receive function detects and locks to an alignment marker payload on PMA service interface lane *x*, the FEC lane number corresponding to the detected alignment marker payload is assigned to the variable FEC_lane_mapping<*x*>. These variables are mapped to the register defined in 45.2.1.105 (1.206).

134.6.9 FEC_symbol_error_counter_*i*

FEC_symbol_error_counter_*i*, where *i*=0 to 1, is a 32-bit counter that counts once for each 10-bit symbol corrected on FEC lane *i* when fec_align_status is true. These variables are mapped to the registers defined in 45.2.1.106 and 45.2.1.107 (1.210 to 1.213).

134.6.10 align_status

This variable is assigned the value of rx_align_status as defined by the PCS deskew state diagram shown in Figure 82–14 (see 134.5.2.2) It is mapped to the bit defined in 45.2.1.102 (1.201.15).

134.6.11 BIP_error_counter_*i*

BIP_error_counter_*i*, where *i*=0 to 3, is a 16-bit counter that holds the BIP error count for PCS lane *i* as calculated by the RS-FEC transmit function (see 134.5.2.4). These variables are mapped to the registers defined in 45.2.1.108 and 45.2.1.109 (1.230 to 1.233).

134.6.12 lane_mapping<*x*>

When the RS-FEC transmit function detects and locks to an alignment marker on FEC service interface lane *x*, the PCS lane number corresponding to the detected alignment marker is assigned to the variable lane_mapping<*x*>. These variables are mapped to the registers defined in 45.2.1.110 and 45.2.1.111 (1.250 to 1.253).

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134.6.13 block_lock<*x*>

These variables are assigned by the block lock state diagram shown in Figure 82–12 (see 134.5.2.1). They are mapped to the registers defined in 45.2.1.112 (1.280).

134.6.14 am_lock<*x*>

These variables are assigned by the alignment marker lock state diagram shown in Figure 82–13 (see 134.5.2.2). They are mapped to the registers defined in 45.2.1.114 (1.282).

134.7 Protocol implementation conformance statement (PICS) proforma for Clause 134, Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 50GBASE-R PHYs[7]

134.7.1 Introduction

The supplier of a protocol implementation that is claimed to conform to Clause 134, Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 50GBASE-R PHYs, shall complete the following protocol implementation conformance statement (PICS) proforma.

A detailed description of the symbols used in the PICS proforma, along with instructions for completing the PICS proforma, can be found in Clause 21.

134.7.2 Identification

134.7.2.1 Implementation identification

Supplier[1]	
Contact point for inquiries about the PICS[1]	
Implementation Name(s) and Version(s)[1,3]	
Other information necessary for full identification—e.g., name(s) and version(s) for machines and/or operating systems; System Name(s)[2]	
NOTE 1—Required for all implementations. NOTE 2—May be completed as appropriate in meeting the requirements for the identification. NOTE 3—The terms Name and Version should be interpreted appropriately to correspond with a supplier's terminology (e.g., Type, Series, Model).	

[7]*Copyright release for PICS proformas*: Users of this standard may freely reproduce the PICS proforma in this subclause so that it can be used for its intended purpose and may further publish the completed PICS.

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134.7.2.2 Protocol summary

Identification of protocol standard	IEEE Std 802.3cd-201x, Clause 134, Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 50GBASE-R PHYs
Identification of amendments and corrigenda to this PICS proforma that have been completed as part of this PICS	
Have any Exception items been required? No [ ] Yes [ ] (See Clause 21; the answer Yes means that the implementation does not conform to IEEE Std 802.3-201x.)	

Date of Statement	

134.7.3 Major capabilities/options

Item	Feature	Subclause	Value/Comment	Status	Support
RS-FEC	Supports 50GBASE-R RS-FEC functionality	134.1.1		M	Yes [ ]
*MD	MDIO capability	45, 134.6	Registers and interface supported	O	Yes [ ] No [ ]
*BEI	Bypass error indication	134.5.3.3	Capability is supported	O	Yes [ ] No [ ]

134.7.4 PICS proforma tables for Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 50GBASE-R PHYs

134.7.4.1 Transmit function

Item	Feature	Subclause	Value/Comment	Status	Support
TF1	Skew tolerance	134.5.2.2	Maximum Skew of 49 ns between PCS lanes and a maximum Skew Variation of 400 ps.	M	Yes [ ]
TF2	Lane reorder	134.5.2.3	Order the PCS lanes according to the PCS lane number	M	Yes [ ]
TF3	64B/66B to 256B/257B transcoder	134.5.2.5	tx_xcoded<256:0> constructed per 134.5.2.5	M	Yes [ ]
TF4	257-bit block transmission order	134.5.2.5	First bit transmitted is bit 0	M	Yes [ ]
TF5	Alignment maker mapping	134.5.2.6	Map to am_tx-mapped<256:0> per 134.5.2.6	M	Yes [ ]
TF6	Pad value	134.5.2.6	Set to 0 or 1 in an alternating pattern	M	Yes [ ]

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Item	Feature	Subclause	Value/Comment	Status	Support
TF7	Alignment marker insertion	134.5.2.6	First 256 message bits to be transmitted from every 1024th codeword	M	Yes [ ]
TF8	Alignment marker insertion point	134.5.2.6	First 257-bit block inserted after am_txmapped corresponds to the four 66-bit blocks received on PCS lanes 0, 1, 2, and 3 that immediately followed the alignment marker on each respective lane	M	Yes [ ]
TF9	Reed-Solomon encoder	134.5.2.7		M	Yes [ ]
TF10	Symbol distribution	134.5.2.8	Distributed to 2 FEC lanes, one 10-bit symbol at a time in a round robin distribution from the lowest to the highest numbered FEC lane	M	Yes [ ]

134.7.4.2 Receive function

Item	Feature	Subclause	Value/Comment	Status	Support
RF1	Skew tolerance	134.5.3.1	Maximum Skew of 180 ns between FEC lanes and a maximum Skew Variation of 4 ns	M	Yes [ ]
RF2	Lane reorder	134.5.2.3	Order the FEC lanes according to the FEC lane number	M	Yes [ ]
RF3	Reed-Solomon decoder for RS(544,514)	134.5.3.3	Corrects any combination of up to t=15 symbol errors in a codeword.	M	Yes [ ]
RF4	Reed-Solomon decoder	134.5.3.3	Capable of indicating when a codeword was not corrected.	M	Yes [ ]
RF5	Error indication function	134.5.3.3	Corrupts 66-bit block synchronization headers for uncorrected errored codewords.	M	Yes [ ]
RF7	Error monitoring while error indication is bypassed	134.5.3.3	When the number of symbols errors in a block of 8 192 codewords exceeds K, corrupt 66-bit block synchronization headers	BEI:M	Yes [ ] N/A [ ]
RF8	Symbol error threshold for RS(544,514)	134.5.3.3	K=6380	BEI:M	Yes [ ] N/A [ ]
RF9	Alignment marker removal	134.5.3.4	am_rxmapped removed prior to transcoding	M	Yes [ ]
RF10	256B/257B to 64B/66B transcoder	134.5.3.5	rx_coded_j<65:0>, j=0 to 3 constructed per 134.5.3.5	M	Yes [ ]

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Item	Feature	Subclause	Value/Comment	Status	Support
RF11	Block distribution	134.5.3.7	One 66-bit block at a time in a round robin fashion from the lowest to the highest numbered PCS lane	M	Yes [ ]
RF12	Alignment marker mapping	134.5.3.7	Map to am_rx_*x*, *x*=0 to 3 per 134.5.3.7	M	Yes [ ]
RF13	Alignment marker insertion point	134.5.3.7	Alignment markers immediately followed by the 66-bit blocks derived from the 257-bit blocks immediately following am_rxmapped	M	Yes [ ]

134.7.4.3 State diagrams

Item	Feature	Subclause	Value/Comment	Status	Support
SD1	SLIP function	134.5.4.2.2	Ensure that all possible block positions are evaluated	M	Yes [ ]
SD2	Synchronization process	134.5.4.3	One instance per FEC lane per **Figure 91–8**	M	Yes [ ]
SD3	Alignment process	134.5.4.3	Per Figure 91–9	M	Yes [ ]

134.7.4.4 Delay Constraints

Item	Feature	Subclause	Value/Comment	Status	Support
TIM1	RS-FEC Delay Constraint	134.4	No more than 25 600 BT for sum of transmit and receive path delays.	M	Yes [ ]

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First Named Inventor/Applicant Name:	Junqing SUN
Customer Number:	63467
Filer:	Daniel Joseph Krueger/Shanay Hines
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Attorney Docket Number:	20160.0031.NPUS00
Receipt Date:	09-JUN-2020
Filing Date:	27-AUG-2019
Time Stamp:	22:38:04
Application Type:	Utility under 35 USC 111(a)

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Warnings:					
Information:					
3	Other Reference-Patent/App/Search documents	NPL_0010PCT000_12062017_ISRWO.pdf	3489196 629388a8f6060010c75c4b4c72d612a6f06f 14f4	no	12
Warnings:					
Information:					
4	Other Reference-Patent/App/Search documents	NPL_0011NPUS00_01242018_NFOA.pdf	159296 4707e5b25b32ca3ee1f2011d552d283661a 9b1ac	no	13
Warnings:					
Information:					
5	Non Patent Literature	NPL_Reed_Solomon_100GBASE.pdf	715949 d8628e1a7325c0063526e258993796059e4 493c5	no	33
Warnings:					
Information:					
6	Other Reference-Patent/App/Search documents	NPL_0011NPUS00_06082018_NOA.pdf	1103434 e35e15347e90c9b9fdb6955d38fa0e775cb 186ae	no	16
Warnings:					
Information:					
7	Non Patent Literature	Clause_94.pdf	416230 a48130865d9c74261e1c061a79e9a8e194a 396c2	no	39
Warnings:					
Information:					
8	Non Patent Literature	_133_1.pdf	308981 a561f5d75c8a4fa454c1c260e5d180d97795 bc79	no	10
Warnings:					
Information:					

9	Non Patent Literature	_136_1.pdf	1024687 a6345920856e28130965d38c29476ff78c5a359a	no	32
Warnings:					
Information:					
10	Non Patent Literature	_134_1.pdf	445760 057b9663a3937c517069bfd70c0043a41e2a2cba	no	18
Warnings:					
Information:					
			Total Files Size (in bytes):	17358052	

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.

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

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	16552927
Filing Date	2019-08-27
First Named Inventor	Junqing SUN
Art Unit	2632
Examiner Name	Malek, Leila
Attorney Docket Number	20160.0031.NPUS00

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	8301036	B2	2012-10-30	He	
	2	9071479	B2	2015-06-30	Qian et al.	
	3	9935800	B1	2018-04-03	He	
	4	9385859	B2	2016-07-05	Kuan et al.	
	5	10212260	B2	2019-02-19	Sun	

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

U.S.PATENT APPLICATION PUBLICATIONS Remove

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	20200076651	A1	2020-03-05	SUN et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16552927
	Filing Date	2019-08-27
	First Named Inventor	Junqing SUN
	Art Unit	2632
	Examiner Name	Malek, Leila
	Attorney Docket Number	20160.0031.NPUS00

	2	20130343400	A1	2014-03-27	Lusted et al.	
	3	20140086264	A1	2014-03-27	Lusted et al.	
	4	20140146833	A1	2014-05-29	Lusted et al.	
	5	20150003505	A1	2015-01-01	Lusted et al.	
	6	20160337114	A1	2016-11-17	Baden et al.	

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]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]
	1							

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

NON-PATENT LITERATURE DOCUMENTS Remove

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	Information Technology - Open Systems Interconnection - Basic Reference Model: The Basic Model, 1994	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16552927
	Filing Date	2019-08-27
	First Named Inventor	Junqing SUN
	Art Unit	2632
	Examiner Name	Malek, Leila
	Attorney Docket Number	20160.0031.NPUS00

	2	International Search Report dated December 6, 2017 in International Application No. PCT/CN2017/075961	
	3	Non-Final Office Action dated January 24, 2018 in 15/487,045	
	4	Reed-Solomon Forward Error Correction (RS-FEC) Sublayer for 100GBASE-R PHYs.	
	5	Notice of Allowance dated June 8, 2018 in Application No. 15/487,045	
	6	"Physical Coding Sublayer (PCS) for 64B/66B, type 50GBASE-R" Draft Amendment to IEEE Std 802.3-2015, February 3, 2017, pp. 132-141, 10 pgs.	
	7	"Physical Medium Attachment (PMA) sublayer, Physical Medium Dependent (PMD) sublayer, and baseband medium, type 1000GBASE-KP4," IEEE Standard for Ethernet, Section Six, pp. 481-519, 39 pgs.	
	8	"Physical Medium Dependent (PMD) sublayer and baseband medium, type 50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4," Draft Amendment to IEEE Std 802.3-2015, February 3, 2017, pp. 184-215, 32 pgs.	
	9	"Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 50GBASE-R PHYs," Draft Amendment to IEEE Std 802.3-2015, February 3, 2017, pp. 142-159, 18 pgs.	

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	16552927
	Filing Date	2019-08-27
	First Named Inventor	Junqing SUN
	Art Unit	2632
	Examiner Name	Malek, Leila
	Attorney Docket Number	20160.0031.NPUS00

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	/Dan Krueger/	Date (YYYY-MM-DD)	2020-06-09
Name/Print	Daniel Krueger	Registration Number	42771

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.

Electronic Acknowledgement Receipt

EFS ID:	39674203
Application Number:	16552927
International Application Number:	
Confirmation Number:	1683
Title of Invention:	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS
First Named Inventor/Applicant Name:	Junqing SUN
Customer Number:	63467
Filer:	Daniel Joseph Krueger/Shanay Hines
Filer Authorized By:	Daniel Joseph Krueger
Attorney Docket Number:	20160.0031.NPUS00
Receipt Date:	09-JUN-2020
Filing Date:	27-AUG-2019
Time Stamp:	22:51:37
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	SB08_20160-0031_1.pdf	613024 9db203a2b157e9cabcddd92645c9a2e5d8a171ae	no	5

Warnings:

Information:	
Total Files Size (in bytes):	613024

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 NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY.DOCKET NO./TITLE	REQUEST ID
16/552,927	08/27/2019	CREDO TECHNOLOGY GROUP LIMITED	20160.0031.NPUS00	115316

Acknowledgement of Loss of Entitlement to Entity Status Discount

The entity status change request below filed through Private PAIR on 06/25/2020 has been accepted.

CERTIFICATIONS:

Change of Entity Status:

X Applicant changing to regular undiscounted fee status.

NOTE: Checking this box will be taken to be notification of loss of entitlement to small or micro entity status, as applicable.

This portion must be completed by the signatory or signatories making the entity status change in accordance with 37 CFR 1.4(d)(4).

Signature:	/Daniel J. Krueger/
Name:	Daniel J. Krueger
Registration Number:	42771

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.
16/552,927	08/27/2019	Junqing SUN	20160.0031.NPUS00	1683

63467 7590 07/09/2020

Ramey & Schwaller, LLP
5020 Montrose Blvd.
Suite 800
Houston, TX 77006

EXAMINER	
MALEK, LEILA	

ART UNIT	PAPER NUMBER
2632	

NOTIFICATION DATE	DELIVERY MODE
07/09/2020	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):

tevenbly@rameyfirm.com
uspto@rameyfirm.com
wramey@rameyfirm.com

Marvell Semiconductor, Inc. - Ex. 1002, Page 000331

Office Action Summary	Application No. 16/552,927	Applicant(s) SUN et al.	
	Examiner LEILA MALEK	Art Unit 2632	AIA (FITF) Status Yes

-- 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 08/27/2019.

☐ 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) 1-20 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) 1,6-10. and 17-19 is/are rejected.

8) ☑ Claim(s) 2-5,11-16 and 20 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 08/27/2019 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: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Priority

2. Applicant's claim for the benefit of a prior-filed application under 35 U.S.C. 119(e) or under 35 U.S.C. 120, 121, 365(c), or 386(c) is acknowledged.

Information Disclosure Statement

3. The information disclosure statements submitted on 06/09/2020 have been considered and made of record by the examiner.

Claim Rejections - 35 USC § 112

> The following is a quotation of 35 U.S.C. 112(b):
> (b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.
>
> The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:
> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

4. Claims 6 and 7 recite the limitation "the performance characteristic". There is insufficient antecedent basis for this limitation in the claim.

Claim Rejections - 35 USC § 103

In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

5. Claims 1 and 8 are rejected under 35 U.S.C. 103 as being unpatentable over Kolze (US 2013/0223506), in view of Thirumoorthy (US 2010/0232493).

As to claim 1, Kolze discloses a method that comprises, in a transceiver (see paragraph 0042): selecting one of multiple pre-equalizer settings to specify initial pre-equalizer coefficient values (see paragraphs 0075, 0077, and Fig. 13, blocks 1310 and 1320); updating the initial pre-equalizer coefficient values during a training phase (see paragraph 0079 and Fig. 13, blocks 1330, 1340, and 1350, wherein the channel monitoring phase associated with blocks 1330 and 1340 is interpreted as a training phase); and using the updated pre-equalizer coefficient values to convey a transmit data stream (see Fig. 12, blocks 1230 and 1240 and paragraph 0076). Kolze discloses all the subject matters claimed in claim 1, except that the coefficients are stored in registers. Thirumoorthy, in the same field of endeavor, discloses a transceiver in a communication system comprising an equalizer that includes an n-tap FIR filter having n coefficients (see Fig. 2, block 218 and paragraphs 0035-0036, 0054, 0062, and 0088), where the coefficients of the equalizer are stored in coefficient registers that are accessible by the equalizer (see paragraphs 0036, 0054, 0062, and 0088). It would have been obvious to one of ordinary skill in the art before the effective filing date of the invention was made to modify the teachings of Kolze as suggested by Thirumoorthy and

store the coefficients of the filter (e.g., equalizer or pre-equalizer) in multiple registers in order organize and control the coefficients more effectively and independently. Athough Thirumoorthy does not expressly disclose selecting one of the registers, Kolze discloses selecting one of multiple pre-equalizer settings to specify initial pre-equalizer coefficient values and Thirumoorthy discloses saving the coefficients in different registers. One of ordinary skill in the art before the effective filing date of the invention was made would have recognized that when different coefficient sets are stored in different registers, selecting a coefficient set is equivalent to selecting the register associated with that coefficient set. Therefore, the combination of the Kolze's and Thirumoorthy's teaching covers all the limitations cited in claim 1.

As to claim 8, Kolze discloses updating the initial pre-equalizer coefficient values (see paragraph 0079 and Fig. 13, blocks 1330, 1340, and 1350). Thirumoorthy also discloses updating the registers with the updated pre-equalizer coefficient values (see paragraph 0088 and Fig. 9, blocks 916 and 918). It would have been obvious to one of ordinary skill in the art before the effective filing date of the invention was made to modify Kolze's teaching as suggested by Thirumoorthy and update the selected register with the updated pre-equalizer coefficient values in order to make sure that the register contains the most updated version of the pre-equalizer coefficients and increase the reliability of the system.

6. Claims 9, 10, and 17-19, are rejected under 35 U.S.C. 103 as being unpatentable over Kolze and Thirumoorthy, further in view of Binder et al. (hereinafter, referred to as Binder) (US 2013/0201316).

As to claim 9, Kolze discloses a transceiver (see paragraph 0042) including: one or more transmit filters to each pre-equalize a corresponding serial symbol stream (see Fig. 6, see all the pre-equalizers) and a controller using one of pre-equalizer settings to set initial coefficient values for the one or more transmit filters (see Fig. 13 and paragraphs 0075, 0077-0079 and 0086). Kolze discloses all the subject matters claimed in claim 9, except that the communication system comprising a port connector coupling a port transceiver to a pluggable module transceiver, where the pre-equalized streams are being transmitted to the port transceiver. Kolze also does not disclose a controller having multiple registers, each of the multiple registers containing a set of initial coefficient values, the controller using one of the registers to set initial coefficient values. Thirumoorthy, in the same field of endeavor, discloses a transceiver in a communication system comprising an equalizer that includes an n-tap FIR filter having n coefficients (see Fig. 2, block 218 and paragraphs 0035-0036, 0054, 0062, and 0088), where the coefficients of the equalizer are stored in coefficient registers that are accessible by the equalizer (see paragraphs 0036, 0054, 0062, and 0088). It would have been obvious to one of ordinary skill in the art before the effective filing date of the invention was made to modify the teachings of Kolze as suggested by Thirumoorthy and store the coefficients of the filter (e.g., equalizer or pre-equalizer) in multiple registers in order organize and control the coefficients more effectively and independently. Thirumoorthy does not expressly disclose selecting one of the registers. Kolze discloses selecting one of multiple pre-equalizer settings to specify initial pre-equalizer coefficient values and Thirumoorthy discloses saving the coefficients in different registers. One of ordinary skill in the art before the effective filing date of the invention was made would

have recognized that when different coefficient sets are stored in different registers, selecting a coefficient set by the controller is equivalent to selecting the register associated with that coefficient set. Therefore, the combination of the Kolze's and Thirumoorthy's teaching covers all the limitations cited in claim 9 associated with selecting a register. Kolze shows that the pre-equalized signals are transmitted to a network (see Fig. 5). Also as previously mentioned, Kolze discloses a transceiver (see paragraph 0042). Kolze and Thirumoorthy disclose all the subject matters claimed in claim 9, except that the communication system comprising a port connector coupling a port transceiver to a pluggable module transceiver, where the pre-equalized streams are being transmitted to the port transceiver. Binder, in the same field of endeavor, discloses a communication system that comprises a transceiver communicating over a network (see paragraph 0041). Binder further discloses that the transceiver is coupled to a port for interfacing and communicating over a network (see paragraphs 0041 and 0273). Binder also discloses that the communication system comprising a port connector coupling a port transceiver to a transceiver (see paragraph 0033, last five lines, paragraph 0041, last four lines, paragraph 0043, last four lines, and paragraphs 0119 and 0172). Binder discloses that the transceiver is a modem (see paragraph 0050). Even though Binder does not expressly disclose that the transceiver (modem) is pluggable, however, it would have been extremely recognizable to one of ordinary skill in the art that all the modems are pluggable devices. It would have been obvious to one of ordinary skill in the art before the effective filing date of the invention was made to make the modem (transceiver) pluggable in order to enable the modem (transceiver) to serve its function. It would have been obvious to one of ordinary skill in the art before

the effective filing date of the invention was made to modify Kolze's and Thirumoorthy's teaching as suggested by Binder in order to enable the transceiver to communicate with the network.

As to claim 10, although Thirumoorthy does not expressly disclose selecting one of the registers by the transceiver, Kolze discloses selecting one of multiple pre-equalizer settings, by the transceiver, to specify initial pre-equalizer coefficient values and Thirumoorthy discloses saving the coefficients in different registers. One of ordinary skill in the art before the effective filing date of the invention was made would have recognized that the when different coefficient sets are stored in different registers, selecting a coefficient set is equivalent to selecting the register associated with that coefficient set. Therefore, the combination of the Kolze's and Thirumoorthy's teaching covers all the limitations cited in claim 10.

As to claim 17, Kolze discloses that the transceiver updates the initial pre-equalizer coefficient values of the one or more pre-equalizers (see paragraph 0079 and Fig. 13, blocks 1330, 1340, and 1350).

As to claim 18, Kolze discloses updating the initial pre-equalizer coefficient values during (see paragraph 0079 and Fig. 13, blocks 1330, 1340, and 1350). Thirumoorthy also discloses updating the registers with the updated pre-equalizer coefficient values (see paragraph 0088 and Fig. 9, blocks 916 and 918). It would have been obvious to one of ordinary skill in the art before the effective filing date of the invention was made to modify Kolze's teaching as suggested by Thirumoorthy and update the selected register with the updated pre-equalizer coefficient values in order to

make sure that the register contains the most updated version of the pre-equalizer coefficients and increase the reliability of the system.

As to claim 19, Kolze discloses a transceiver (see paragraph 0042) including: one or more transmit filters to each pre-equalize a corresponding serial symbol stream (see Fig. 6, see all the pre-equalizers) and a controller using one of pre-equalizer settings to set initial coefficient values for the one or more transmit filters (see Fig. 13 and paragraphs 0075, 0077-0079 and 0086). Kolze discloses all the subject matters claimed in claim 19, except that the pre-equalized streams are being transmitted to a port transceiver. Kolze also does not disclose a controller having multiple registers, each of the multiple registers containing a set of initial coefficient values, the controller using one of the registers to set initial coefficient values. Thirumoorthy, in the same field of endeavor, discloses a transceiver in a communication system comprising an equalizer that includes an n-tap FIR filter having n coefficients (see Fig. 2, block 218 and paragraphs 0035-0036, 0054, 0062, and 0088), where the coefficients of the equalizer are stored in coefficient registers that are accessible by the equalizer (see paragraphs 0036, 0054, 0062, and 0088). It would have been obvious to one of ordinary skill in the art before the effective filing date of the invention was made to modify the teachings of Kolze as suggested by Thirumoorthy and store the coefficients of the filter (equalizer or pre-equalizer) in multiple registers in order organize and control the coefficients more effectively and independently. Although Thirumoorthy does not expressly disclose selecting one of the registers, Kolze discloses selecting one of multiple pre-equalizer settings to specify initial pre-equalizer coefficient values and Thirumoorthy discloses saving the coefficients in different registers. One of ordinary skill

in the art before the effective filing date of the invention was made would have recognized that when different coefficient sets are stored in different registers, selecting a coefficient set by the controller is equivalent to selecting the register associated with that coefficient set by the controller. Therefore, the combination of the Kolze's and Thirumoorthy's teaching covers all the limitations cited in claim 19 associated with selecting a register. Kolze shows that the pre-equalized signals are transmitted to a network (see Fig. 5). Also as previously mentioned, Kolze discloses a transceiver (see paragraph 0042). Kolze and Thirumoorthy disclose all the subject matters claimed in claim 19, except that pre-equalized streams are being transmitted to a port transceiver. Binder, in the same field of endeavor, discloses a communication system that comprises a transceiver communicating over a network (see paragraph 0041). Binder discloses that the transceiver is coupled to a port for interfacing and communicating over a network (see paragraphs 0041 and 0273). It would have been obvious to one of ordinary skill in the art before the effective filing date of the invention was made to modify Kolze's and Thirumoorthy's teaching as suggested by Binder in order to enable the transceiver to communicate with the network.

Allowable Subject Matter

7. Claims 2-5, 11-16, and 20 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Conclusion

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to LEILA MALEK whose telephone number is (571)272-8731. The examiner can normally be reached on Monday-Friday 8:30am-4:30pm.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chieh Fan can be reached on 571-272-3042. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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LEILA . MALEK
Examiner
Art Unit 2632

/LEILA MALEK/
Primary Examiner, Art Unit 2632

Notice of References Cited	Application/Control No. 16/552,927	Applicant(s)/Patent Under Reexamination SUN et al.	
	Examiner LEILA MALEK	Art Unit 2632	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20130223506-A1	08-2013	Kolze; Thomas J.	H04L27/01	375/232
*	B	US-20100232493-A1	09-2010	Thirumoorthy; Hari	H04L27/0014	375/232
*	C	US-20130201316-A1	08-2013	BINDER; Yehuda	H04L67/12	348/77
	D					
	E					
	F					
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*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/552,927	SUN et al.
	Examiner	Art Unit
	LEILA MALEK	2632

CPC - Searched*		
Symbol	Date	Examiner

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

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Search Notes		
Search Notes	Date	Examiner
EAST, IEEE, IDS, Inventor Name Search	07/05/2020	L.M.

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

Marvell Semiconductor, Inc. - Ex. 1002, Page 000344

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/552,927	SUN et al.
	Examiner	**Art Unit**
	LEILA MALEK	2632

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

CLAIMS										
☐ Claims renumbered in the same order as presented by applicant						☐ CPA		☐ T.D.		☐ R.1.47
CLAIM		**DATE**								
Final	Original	07/05/2020								
	1	✓								
	2	O								
	3	O								
	4	O								
	5	O								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
	10	✓								
	11	O								
	12	O								
	13	O								
	14	O								
	15	O								
	16	O								
	17	✓								
	18	✓								
	19	✓								
	20	O								

Marvell Semiconductor, Inc. - Ex. 1002, Page 000345

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

PTO/SB/08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	16552927
Filing Date	2019-08-27
First Named Inventor	Junqing SUN
Art Unit	2632
Examiner Name	Malek, Leila
Attorney Docket Number	20160.0031.NPUS00

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
/L.M/	1	8301036	B2	2012-10-30	He	
/L.M/	2	9071479	B2	2015-06-30	Qian et al.	
/L.M/	3	9935800	B1	2018-04-03	He	
/L.M/	4	9385859	B2	2016-07-05	Kuan et al.	
/L.M/	5	10212260	B2	2019-02-19	Sun	

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/L.M/	1	20200076651	A1	2020-03-05	SUN et al.	

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	First Named Inventor	Junqing SUN
	Art Unit	2632
	Examiner Name	Malek, Leila
	Attorney Docket Number	20160.0031.NPUS00

/L.M/	2	20130343400	A1	2014-03-27	Lusted et al.	
/L.M/	3	20140086264	A1	2014-03-27	Lusted et al.	
/L.M/	4	20140146833	A1	2014-05-29	Lusted et al.	
/L.M/	5	20150003505	A1	2015-01-01	Lusted et al.	
/L.M/	6	20160337114	A1	2016-11-17	Baden et al.	

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/L.M/	1	Information Technology - Open Systems Interconnection - Basic Reference Model: The Basic Model, 1994	

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	Filing Date	2019-08-27
	First Named Inventor	Junqing SUN
	Art Unit	2632
	Examiner Name	Malek, Leila
	Attorney Docket Number	20160.0031.NPUS00

/L.M/	2	International Search Report dated December 6, 2017 in International Application No. PCT/CN2017/075961	
/L.M/	3	Non-Final Office Action dated January 24, 2018 in 15/487,045	
/L.M/	4	Reed-Solomon Forward Error Correction (RS-FEC) Sublayer for 100GBASE-R PHYs.	
/L.M/	5	Notice of Allowance dated June 8, 2018 in Application No. 15/487,045	
/L.M/	6	"Physical Coding Sublayer (PCS) for 64B/66B, type 50GBASE-R" Draft Amendment to IEEE Std 802.3-2015, February 3, 2017, pp. 132-141, 10 pgs.	
/L.M/	7	"Physical Medium Attachment (PMA) sublayer, Physical Medium Dependent (PMD) sublayer, and baseband medium, type 1000GBASE-KP4," IEEE Standard for Ethernet, Section Six, pp. 481-519, 39 pgs.	
/L.M/	8	"Physical Medium Dependent (PMD) sublayer and baseband medium, type 50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4," Draft Amendment to IEEE Std 802.3-2015, February 3, 2017, pp. 184-215, 32 pgs.	
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Examiner Signature	/LEILA MALEK/	Date Considered	07/05/2020

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	First Named Inventor	Junqing SUN
	Art Unit	2632
	Examiner Name	Malek, Leila
	Attorney Docket Number	20160.0031.NPUS00

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

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Signature	/Dan Krueger/	Date (YYYY-MM-DD)	2020-06-09
Name/Print	Daniel Krueger	Registration Number	42771

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Bibliographic Data

Application No: 16/552,927

Foreign Priority claimed: ○ Yes ◉ No

35 USC 119 (a-d) conditions met: ☐ Yes ☑ No ☐ Met After Allowance

Verified and Acknowledged: /LEILA MALEK/ (Examiner's Signature) L.M. (Initials)

Title: SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
08/27/2019	375	2632	20160.0031.NPUS00
RULE			

APPLICANTS

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INVENTORS

Junqing SUN Fremont, CA, UNITED STATES

Haoli QIAN Fremont, CA, UNITED STATES

CONTINUING DATA

This application has PRO of 62723701 08/28/2018

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Application Number	16552927
Filing Date	2019-08-27
First Named Inventor	Junqing SUN
Art Unit	2632
Examiner Name	Malek, Leila
Attorney Docket Number	20160.0031.NPUS00

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/L.M/	2	9071479	B2	2015-06-30	Qian et al.	
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/L.M/	2	20130343400	A1	2014-03-27	Lusted et al.	

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/L.M/	3	20140086264	A1	2014-03-27	Lusted et al.	
/L.M/	4	20140146833	A1	2014-05-29	Lusted et al.	
/L.M/	5	20150003505	A1	2015-01-01	Lusted et al.	
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/L.M/	1	Information Technology - Open Systems Interconnection - Basic Reference Model: The Basic Model, 1994	
/L.M/	2	International Search Report dated December 6, 2017 in International Application No. PCT/CN2017/075961	

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/L.M/	4	Reed-Solomon Forward Error Correction (RS-FEC) Sublayer for 100GBASE-R PHYs.	
/L.M/	5	Notice of Allowance dated June 8, 2018 in Application No. 15/487,045	
/L.M/	6	"Physical Coding Sublayer (PCS) for 64B/66B, type 50GBASE-R" Draft Amendment to IEEE Std 802.3-2015, February 3, 2017, pp. 132-141, 10 pgs.	
/L.M/	7	"Physical Medium Attachment (PMA) sublayer, Physical Medium Dependent (PMD) sublayer, and baseband medium, type 1000GBASE-KP4," IEEE Standard for Ethernet, Section Six, pp. 481-519, 39 pgs.	
/L.M/	8	"Physical Medium Dependent (PMD) sublayer and baseband medium, type 50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4," Draft Amendment to IEEE Std 802.3-2015, February 3, 2017, pp. 184-215, 32 pgs.	
/L.M/	9	"Reed-Solomon Forward Error Correction (RS-FEC) sublayer for 50GBASE-R PHYs," Draft Amendment to IEEE Std 802.3-2015, February 3, 2017, pp. 142-159, 18 pgs.	

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

EXAMINER SIGNATURE

Examiner Signature	/LEILA MALEK/	Date Considered	07/05/2020

*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	16552927
	Filing Date	2019-08-27
	First Named Inventor	Junqing SUN
	Art Unit	2632
	Examiner Name	Malek, Leila
	Attorney Docket Number	20160.0031.NPUS00

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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	/Dan Krueger/	Date (YYYY-MM-DD)	2020-06-09
Name/Print	Daniel Krueger	Registration Number	42771

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PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L10	49	("10212260"|"20130343400"|"20140086264"|"20140146833"|"20150003505"|"20160337114"|"20200076651"|"8301036"|"9071479"|"9385859"|"9935800").PN.	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 11:29 AM
L11	11	("10212260"|"20130343400"|"20140086264"|"20140146833"|"20150003505"|"20160337114"|"20200076651"|"8301036"|"9071479"|"9385859"|"9935800").PN.	US-PGPUB; USPAT	OR	ON	ON	2020/06/22 12:04 PM
L12	11	("10212260"|"20130343400"|"20140086264"|"20140146833"|"20150003505"|"20160337114"|"20200076651"|"8301036"|"9071479"|"9385859"|"9935800").PN.	US-PGPUB; USPAT	OR	ON	ON	2020/06/22 12:15 PM
L13	2	12 AND (pre$1equaliz$3 near3 coefficient$1)	US-PGPUB; USPAT	OR	ON	ON	2020/06/22 12:15 PM
L14	2	12 AND (pre$1equaliz$3 near3 (tap$1 OR weight$1 OR coefficient$1))	US-PGPUB; USPAT	OR	ON	ON	2020/06/22 12:16 PM
L15	0	(select$3 OR pick$3 OR obtain$3 OR choos$3) near2 (set OR group) near3 (pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 12:21 PM
L16	91	(select$3 OR pick$3 OR obtain$3 OR choos$3) near4 (pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 12:21 PM
L17	1	16 AND c2m	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:07 PM
L18	1	(select$3 OR pick$3 OR obtain$3 OR choos$3) near4 (pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO;	OR	ON	ON	2020/06/22 04:08 PM

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		AND c2m	DERWENT; IBM_TDB				
L19	1	(pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1) AND c2m	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:09 PM
L20	1	(pre$1equaliz$3) AND c2m adj1 (channels OR path$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:10 PM
L21	2	(pre$1equaliz$3) AND c2m	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:10 PM
L22	230	(pre$1equaliz$3) AND (channel adj1 models)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:48 PM
L23	44	(pre$1equaliz$3) WITH (channel adj1 models)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:49 PM
L24	0	23 AND (different OR multiple OR plurality) adj2 (channel adj1 models)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:51 PM
L25	3	(pre$1equaliz$3) WITH (channel adj1 models)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	ON	2020/06/22 04:54 PM
L26	8	(pre$1equaliz$3 near3 (coefficient$1 OR tap$1 OR weight$1)) WITH (channel adj1 model$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:56 PM
L27	44	(pre$1equaliz$3) WITH (channel adj1 model$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 05:24 PM
L28	1	serdes AND c2m AND pre$1equaliz$3	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 10:09 AM
L29	1	serdes AND c2m near3 channel$1	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 10:10 AM
L30	12	serdes AND c2m	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO;	OR	ON	ON	2020/06/23 10:10 AM

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			DERWENT; IBM_TDB				
L31	6	serdes AND c2m AND (coefficient$1 OR weight$1 OR tap$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 11:32 AM
L32	0	serdes AND c2c AND pre$1equaliz$3	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 11:37 AM
L33	45	serdes AND pre$1equaliz$3	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 11:37 AM
L34	13	serdes AND pre$1equaliz$3 AND ((select$3 OR choos$3 OR pick$3 OR determin$3) near7 pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 11:38 AM
L35	524	(channel near2 response) near6 (channel adj1 model)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 11:42 AM
L36	10	pre$1equaliz$3 SAME (coefficient$1 OR tap$1 OR weight$1) SAME (channel adj1 model$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 11:45 AM
L37	4	(select$3 OR choos$3 OR pick$3 OR determin$3) near5 pre$1equaliz$3 SAME (channel adj1 model$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 11:48 AM
L38	0	(select$3 OR choos$3 OR pick$3 OR determin$3) near4 (register OR memory OR storage) SAME (pre$1equaliz4)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 03:17 PM
L39	43	(select$3 OR choos$3 OR pick$3 OR determin$3) near4 (register OR memory OR storage) SAME (pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 03:17 PM
L40	6	(select$3 OR choos$3 OR pick$3 OR determin$3) near4 (table) SAME (pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 03:52 PM
L41	9	(select$3 OR pick$3 OR	US-PGPUB; USPAT;	OR	ON	ON	2020/06/23

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		obtain$3 OR choos$3 OR determin$3 OR decid$3) near2 (set OR group OR table) near3 (coefficient$1 OR tap$1 OR weight$1) SAME pre$1equaliz$3	USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB				05:09 PM
L42	2	updat$3 near4 (coefficient$1 OR tap$1 OR weight$1) near4 (pre$1equaliz$3) WITH (training adj1 (mode OR phase OR period))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 05:49 PM
L43	8	updat$3 near4 (coefficient$1 OR tap$1 OR weight$1) near4 (pre$1equaliz$3) WITH (training)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 05:50 PM
L44	3	updat$3 near4 (coefficient$1 OR tap$1 OR weight$1) near4 (pre$1equaliz$3) WITH (initializ$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 01:56 PM
L45	119	(select$3 OR pick$3 OR obtain$3 OR choos$3) near2 (set OR group OR table OR register) near3 (pre$1distort$3) near3 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 02:46 PM
L46	0	(select$3 OR pick$3 OR obtain$3 OR choos$3) near2 (set OR group OR table OR register) near3 (pre$1distort$3) near3 (coefficient$1 OR tap$1 OR weight$1) SAME (channel adj1 model)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 02:49 PM
L47	2	(select$3 OR pick$3 OR obtain$3 OR choos$3) near2 (set OR group OR table OR register) near3 (pre$1distort$3) near3 (coefficient$1 OR tap$1 OR weight$1) AND (channel adj1 model)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 02:49 PM
L48	4115	(sav$3 OR stor$3) near4 (coefficient$1 OR tap$1 OR weight$1) near3 (different OR independent OR plurality OR several) near3 (register$1 OR table$1 OR memor$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 03:12 PM

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L49	17	(sav$3 OR stor$3) near4 (equalizer OR pre$1equalizer) near2 (coefficient$1 OR tap$1 OR weight$1) near3 (different OR independent OR plurality OR several OR multiple) near3 (register$1 OR memor$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 03:14 PM
L50	51	(registers OR memories OR (memory adj1 units)) near4 (equalizer OR pre$1equalizer) near2 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	ON	2020/06/24 03:19 PM
L51	4	(registers OR memories OR (memory adj1 units)) near4 (pre$1equaliz$5) near2 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	ON	2020/06/24 03:50 PM
L52	11	(select$3 OR choos$3 OR pick$3) near3 (pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 04:18 PM
L53	2	(select$3 OR choos$3 OR pick$3) near5(initial) near4 (pre$1equaliz$3) near5 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 04:22 PM
L54	29	(select$3 OR choos$3 OR pick$3) near4 (pre$1equaliz$3) near5 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 04:28 PM
L55	23	54 AND (updat$3 OR adjust$3) near5 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 04:31 PM
L56	8	(coefficient$1 OR tap$1 OR weight$1) near6 pre$1equaliz$3 WITH (channel adj1 model)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:09 PM
L57	31	(coefficient$1 OR tap$1 OR weight$1) near6 pre$1equaliz$3 WITH (impulse adj1 response adj3 channel)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:13 PM
L58	39	(coefficient$1 OR tap$1 OR weight$1) near6	US-PGPUB; USPAT; USOCR; FIT (CN, FR,	OR	ON	ON	2020/06/24 06:15 PM

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		pre$1equaliz$3 WITH ((impulse adj1 response adj3 channel) OR (channel adj1 model))	WO); FPRS; EPO; JPO; DERWENT; IBM_TDB				
L59	0	L58 AND (EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 ((channel adj1 impulse) OR (channel adj1 model))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:17 PM
L60	215	(coefficient$1 OR tap$1 OR weight$1) WITH (EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 ((channel adj1 impulse) OR (channel adj1 model))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:18 PM
L61	0	(coefficient$1 OR tap$1 OR weight$1) WITH (EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 ((channel adj1 impulse) OR (channel adj1 model)) AND (pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:18 PM
L62	66	(coefficient$1 OR tap$1 OR weight$1) WITH ((EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 channel) AND (pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:19 PM
L63	11	(coefficient$1 OR tap$1 OR weight$1) WITH ((EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 channel) AND ((pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:19 PM
L64	8	(coefficient$1 OR tap$1 OR weight$1) WITH (channel adj1 model) AND ((pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:24 PM
L65	1	c2m AND (insertion adj1 loss) AND (package adj1 loss)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:30 PM

L66	2	((coefficient$1 OR tap$1 OR weight$1) near3 pre$1equaliz$3) WITH ((performance adj1 characteristic$1) OR (error adj1 signal adj1 (power OR energy)) OR (bit adj1 error adj1 rate))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:36 PM
L67	0	(sav$3 OR stor$3) near3 (updated OR adjusted) adj3 (coefficient$1 OR tap$1 OR weight$1) near3 pre$1equaliz$3	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:41 PM
L68	30	(sav$3 OR stor$3) near3 (updated OR adjusted) adj3 (coefficient$1 OR tap$1 OR weight$1) near3 equaliz$3	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:41 PM
L69	11	(port adj1 connector) WITH transceiver WITH pluggable	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:49 PM
L70	2	(port adj1 connector) WITH transceiver WITH pluggable AND pre$1equalizer$1	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:49 PM
L71	2	(port adj1 connector) WITH transceiver WITH pluggable AND pre$1equaliz$3	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:49 PM
L72	0	(chip$1to$1module OR c2m) AND (port adj1 connect$3) AND (plug$4 near3 transceiver)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:50 PM
L73	364	(port adj1 connect$3) AND (plug$4 near3 transceiver)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:51 PM
L74	13	(port adj1 connect$3) WITH (plug$4 near3 transceiver)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:23 AM
L75	3	(port adj1 connect$3) WITH (plug$4 near3 transceiver) AND (filter OR pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:23 AM
L76	13	(port adj1 connect$3) WITH (plug$4 near3 transceiver)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:27 AM

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L77	319	(port near2 connect$3) WITH (plug$5 near3 transceiver)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:32 AM
L78	3	(port near2 connect$3) WITH (plug$5 near3 transceiver) WITH (port adj1 transceiver)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:33 AM
L79	2	(pre$1equaliz$3) near3 (coefficients OR taps OR weights OR (coefficient adj1 values) OR (tap adj1 values)) near5 (registers OR (storage adj1 units) OR memories)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	ON	2020/06/25 06:35 AM
L80	4	(pre$1equaliz$3) SAME (coefficients OR taps OR weights OR (coefficient adj1 values) OR (tap adj1 values)) near6 (registers OR (storage adj1 units) OR memories)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	ON	2020/06/25 06:36 AM
L81	1	(pre$1equaliz$3) SAME ((coefficient OR tap OR weight) near2 set) near6 (register$1 OR (storage adj1 unit$1) ormemor$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	ON	2020/06/25 06:46 AM
L82	9	(pre$1equaliz$3) SAME ((coefficient OR tap OR weight) near2 set) near6 (register$1 OR (storage adj1 unit$1) OR memor$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:47 AM
L83	0	(pre$1equaliz$3) SAME (sav$3 OR stor$3) near3 (each OR different OR several OR multiple) adj1 set$1 near3 (coefficient OR tap OR weight)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:51 AM
L84	15	(pre$1equaliz$3) SAME (each OR different OR several OR multiple) adj1 set$1 near3 (coefficient OR tap OR weight)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:52 AM
L85	0	(pre$1equaliz$3) SAME (port adj1 transmitter)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 10:21 AM
L86	0	(pre$1equaliz$3) SAME3	US-PGPUB; USPAT;	OR	ON	ON	2020/06/25

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		(port adj1 transmitter)	USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB				10:21 AM
L87	0	(pre$1equaliz$3) AND (port adj1 transmitter)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 10:22 AM
L88	22	(pre$1equaliz$3) AND (port near2 transmitter)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 10:22 AM
L89	55	(pre$1equaliz$3) AND (port near2 transmit$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 10:24 AM
L90	12	(pre$1equaliz$3) AND (port near2 transceiv$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:24 AM
L91	14	(pre$1equaliz$3) AND (port near3 transceiv$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:27 AM
L92	3177	cable SAME (port near3 transceiv$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:40 AM
L93	1601	cable WITH (port near3 transceiv$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:40 AM
L94	2460	network WITH (port near1 transceiv$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:41 AM
L95	1497	network WITH (port adj1 transceiv$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:41 AM
L96	609	network near5(port adj1 transceiv$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:41 AM
L97	0	network near5 "port adj1 transceiv$3"	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:43 AM
L98	0	"port adj1 transceiv$3"	US-PGPUB; USPAT;	OR	ON	ON	2020/06/25

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			USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB				11:43 AM
L99	0	"port adj1 transceiver"	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:44 AM
L100	4775	"port transceiver"	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:44 AM
L101	550	"port transceiver" near5 network	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:45 AM
L102	483	"port transceiver" near5 network	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	ON	2020/06/25 11:45 AM
L103	1	(select$3 near4 register) WITH pre$1equaliz$3 AND (sun.inv. OR qian.inv.)	US-PGPUB; USPAT	OR	ON	ON	2020/07/03 06:52 AM
L104	1	"20020141347" AND (model WITH coefficient$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 03:32 PM
L105	1	"20020141347" AND (model WITH (coefficient$1 OR tap$1 OR weight$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 03:36 PM
L106	160	(channel adj1 model) near4 (channel adj1 characteristic$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 03:42 PM
L107	7	(channel adj1 model) WITH (pre$1equalizer near3 (tap$1 OR coefficient$1 OR weight$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 04:01 PM
L108	1	"20130223506" AND (pre$1equaliz$3 WITH (fir OR filter$3))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 10:52 PM
L109	839852	20100232493and (control$4 near5 (coefficient$1 OR tap$1 OR register$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 11:14 PM

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L110	0	"20100232493" AND (control$4 near5 (coefficient$1 OR tap$1 OR register$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 11:17 PM
L111	2	"20100232493" AND (control$4 WITH (coefficient$1 OR tap$1 OR register$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 11:17 PM
L112	2	"20100232493" AND (control$4 WITH (coefficient$1 OR tap$1 OR register$1)) AND (register WITH coefficient$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 11:18 PM
L113	1	"20130201316" AND (connector WITH port)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/04 08:44 AM
L114	1	"20130201316" AND (connector SAME port)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/04 08:46 AM
L115	2	"20130201316" AND (plug$4 SAME (modem OR transceiver))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/04 09:03 AM

PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.

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16552927	CTNF	07/09/2020	20160.0031.NPUS00
	892	07/09/2020	20160.0031.NPUS00
	1449	07/09/2020	20160.0031.NPUS00
	1449	07/09/2020	20160.0031.NPUS00

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PATENT APPLICATION INFORMATION RETRIEVAL SYSTEM

Serial No.:	16/552927
Filing Date:	2019-08-27
Confirmation:	1683
Atty Docket:	20160.0031.NPUS00
1st Inventor:	Junqing Sun
Title:	SerDes Pre-equalizer having Adaptable Preset Coefficient Registers
Examiner:	Leila Malek
Art Unit:	2632

RESPONSE TO OFFICE ACTION OF 2020-07-09

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 23313-1450

Dear Sir or Madam:

This paper is submitted in response to the above-identified office action. Please reconsider the rejections in light of the following amendments and remarks.

An Amendment to the Claims begins on page 2.

Remarks begin on page 5.

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Amendment to the Claims

Please amend the claims to read as provided below:

1. (Currently amended) A SerDes communications method that comprises, in a transceiver:

determining a performance characteristic for initial pre-equalizer coefficient values in each of multiple registers;

selecting one of the multiple registers to specify initial pre-equalizer coefficient values for subsequent use;

updating the initial pre-equalizer coefficient values during a training phase; and

using the updated pre-equalizer coefficient values to convey a transmit data stream.

2. (Currently amended) ~~The method of claim 1, wherein~~ A SerDes communications method that comprises, in a transceiver:

selecting one of multiple registers to specify initial pre-equalizer coefficient values, each of the multiple registers ~~corresponds~~ corresponding to a different channel model;

updating the initial pre-equalizer coefficient values during a training phase; and

using the updated pre-equalizer coefficient values to convey a transmit data stream.

3. (Original) The method of claim 2, wherein at least some of the different channel models are for chip-to-module (C2M) channels with different insertion loss and package loss characteristics.

4. (Original) The method of claim 2, wherein at least some of the different channel models presume different types of receiver equalization.

5. (Canceled)

6. (Original) The method of claim 1, wherein the performance characteristic is an error signal energy.

7. (Original) The method of claim 1, wherein the performance characteristic is a bit error rate.

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8. (Original) The method of claim 1, further comprising updating the selected register with the updated pre-equalizer coefficient values.

9. (Currently amended) A chip-to-module communications link that comprises a port connector coupling a port transceiver to a pluggable module transceiver, the pluggable module transceiver including:

one or more transmit filters to each pre-equalize a corresponding serial symbol stream being transmitted to the port transceiver; and

a controller having multiple registers, each of the multiple registers containing a set of initial coefficient values corresponding to a different channel model, the controller using one of the registers to set initial coefficient values for the one or more transmit filters.

10. (Canceled)

11. ~~The communications link of claim 10, wherein~~ A chip-to-module communications link that comprises a port connector coupling a port transceiver to a pluggable module transceiver, the pluggable module transceiver including:

one or more transmit filters to each pre-equalize a corresponding serial symbol stream being transmitted to the port transceiver; and

a controller having multiple registers, each of the multiple registers containing a set of initial coefficient values for which the port transceiver ~~iteratively selects different ones of the multiple registers and~~ determines a performance characteristic ~~for each~~,

the controller using one of the registers selected by the port transceiver to specify the initial coefficient values for the one or more transmit filters.

12. (Original) The communications link of claim 11, wherein the performance characteristic is an error signal energy.

13. (Original) The communications link of claim 11, wherein the performance characteristic is a bit error rate.

14. (Canceled)

15. (Currently amended) The communications link of ~~claim 14~~ claim 9, wherein at

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least some of the different channel models are for chip-to-module (C2M) channels with different insertion loss and package loss characteristics.

16. (Currently amended) The communications link of ~~claim 14~~ claim 9, wherein at least some of the different channel models presume different types of receiver equalization.

17. (Currently amended) The communications link of ~~claim 9~~ claim 11, wherein the port transceiver generates updates for the coefficient values of the one or more transmit filters.

18. (Original) The communications link of claim 17, wherein the controller saves updated coefficient values in one of the registers.

19. (Currently amended) A pluggable module transceiver including:

one or more transmit filters to each pre-equalize a corresponding serial symbol stream being transmitted to a port transceiver; and

a controller having multiple registers, each of the multiple registers containing a set of initial coefficient values corresponding to a different channel model, the controller using one of the registers to set initial coefficient values for the one or more transmit filters.

20. (Canceled)

21 . (New) The pluggable module transceiver of claim 19, wherein the port transceiver determines a performance characteristic for each register.

22. (New) The pluggable module transceiver of claim 21, wherein the performance characteristic is an error signal energy.

23. (New) The pluggable module transceiver of claim 21, wherein the performance characteristic is a bit error rate.

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Remarks

Status of the Claims

Claims 1-20 were pending. Claims 5, 10, 14, and 20 are canceled. Claims 1-2, 9, 11, 15-17, and 19, are amended. New claims 21-23 are added. Claims 1-4, 6-9, 11-13, 15-19, and 21-23 are now pending.

The number of independent claims has increased from 3 to 5. The number of total claims has decreased from 20 to 19.

Rejections Under 35 USC § 112

Claims 6-7 stand rejected under 35 USC § 112 as lacking antecedent basis for "the performance characteristic". These claims depend from independent claim 1, which now provides sufficient antecedent basis. Applicant respectfully submits that this rejection is fully addressed by claim 1 as amended.

Rejections Under 35 USC § 103

Claims 1 and 8 stand rejected under 35 USC § 103 as being unpatentable over US2013/0223506 ("Kolze") in view of US2010/0232493 ("Thirumoorthy").

Claims 9-10 and 17-19 stand rejected under 35 USC § 103 as being unpatentable over Kolze and Thirumoorthy in view of US2013/0201316 ("Binder").

Claim 10 has been canceled. Insofar as the rejections apply to the pending claims as amended, applicant respectfully traverses because the cited art fails to teach or suggest every limitation of the claims.

For example, independent claim 1 has been amended to incorporate limitations from canceled claim 5, which was indicated to contain allowable subject matter. Claim 8 depends from independent claim 1 and is allowable for at least the same reasons.

Independent claim 9 has been amended to incorporate limitations from canceled claim 14, which was indicated to contain allowable subject matter.

Claim 17 has been amended to depend from claim 11, which was indicated to contain allowable subject matter. Claim 18 depends from claim 17 and is allowable for at least the same reasons.

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Independent claim 19 has been amended to incorporate limitations from canceled claim 20, which was indicated to contain allowable subject matter. New claims 21-23 depend from independent claim 19 and are believed to be allowable for at least the same reasons.

Allowable Subject Matter

Claims 2-5, 11-16, and 20 were indicated to contain allowable subject matter.

Claim 2 has been amended into independent form, and accordingly claim 2 and its dependent claims 3-4 are believed to be in condition for allowance.

Claim 5 has been canceled and the relevant limitations incorporated into independent claim 1, which is now believed to be in condition for allowance.

Claim 11 has been amended into independent form, and accordingly claim 11 and its dependent claims 12-13 are believed to be in condition for allowance.

Claims 14 has been canceled and the relevant limitations incorporated into independent claim 9, which is now believed to be in condition for allowance along with its dependent claims 15-16.

Claim 20 has been canceled and the relevant limitations incorporated into independent claim 19, which is now believed to be in condition for allowance.

Conclusion

Applicant appreciates the examiner's careful examination of the present application. The examiner is encouraged to contact the undersigned practitioner if an interview might prove helpful to the examination process.

Respectfully submitted,

/Dan Krueger/ 2020-10-07

_____ _____

Daniel J. Krueger Date
Reg. No. 42,771
(713) 449-9669
Attorney for Applicant

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Houston TX 77006
713-426-3923 x304

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Electronic Acknowledgement Receipt

EFS ID:	40787393
Application Number:	16552927
International Application Number:	
Confirmation Number:	1683
Title of Invention:	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS
First Named Inventor/Applicant Name:	Junqing SUN
Customer Number:	63467
Filer:	Daniel Joseph Krueger/Shanay Hines
Filer Authorized By:	Daniel Joseph Krueger
Attorney Docket Number:	20160.0031.NPUS00
Receipt Date:	07-OCT-2020
Filing Date:	27-AUG-2019
Time Stamp:	19:06:27
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		C031RNF.pdf	135958 3ad0d7fd5aef23f0057119d153f005b78e8a aa6c	yes	6

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	4
	Applicant Arguments/Remarks Made in an Amendment	5	6
Warnings:			
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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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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 16/552,927	Filing Date 08/27/2019	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $100 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $460 =	
☐ 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).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	10/07/2020	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 19	Minus	** 20	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 5	Minus	*** 3	= 2		x $480 =	960
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	960

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/ALLYSON PURNELL/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

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

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

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.
16/552,927	08/27/2019	Junqing SUN	20160.0031.NPUS00	1683

63467 7590 10/14/2020

Ramey & Schwaller, LLP
5020 Montrose Blvd.
Suite 800
Houston, TX 77006

EXAMINER	
MALEK, LEILA	

ART UNIT	PAPER NUMBER
2632	

NOTIFICATION DATE	DELIVERY MODE
10/14/2020	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):

tevenbly@rameyfirm.com
uspto@rameyfirm.com
wramey@rameyfirm.com

Marvell Semiconductor, Inc. - Ex. 1002, Page 000379

NOTICE REQUIRING EXCESS CLAIMS FEES	Application No.	Applicant(s)
	16/552,927	SUN et al.
	Art Unit	AIA (FITF) Status
	OED2	Yes

The excess claim(s) filed on 07 October 2020 is/are not accompanied by the appropriate payment of excess claims fees set forth in 37 CFR 1.16(h)-(j) or 1.492(d)-(f). Excess claims fees are required for each claim in independent form in excess of three (§ 1.16(h)), each claim (whether dependent or independent) in excess of twenty (note that § 1.75(c) indicates how multiple dependent claims are considered for fee calculation purposes) (§ 1.16(i)), and each application that contains a multiple dependent claim (§ 1.16(j)).

Since the application is not under a final rejection, applicant is given a time period of **TWO (2) MONTHS** from the mailing date of this notice to submit either: (1) the fee payment of $ 960.00 , or (2) an amendment in compliance with 37 CFR 1.121 that cancels the excess claim(s), in order to avoid ABANDONMENT. Extensions of this time period may be granted under 37 CFR 1.136, unless the excess claim(s) was/were presented in a preliminary amendment.

☐ 1. The funds in Deposit Account No. _____ are insufficient to cover the entire fee due. The balance is due within the time period set forth in this notice. See note below regarding the appropriate service charge.

☐ 2. The Credit Card payment to cover the entire fee due to Account _____ (**Card type + last 4 digits ONLY**) was refused. The balance is due within the time period set forth in this notice. See note below regarding the appropriate service charge.

☑ 3. The amendment that includes the excess claim(s) has not been entered, since applicant has failed to remit (or authorize charge to a Deposit Account or Credit Card) the fee as indicated on the attached Patent Application Fee Determination Record (PTO/SB/06). Remittance or authorization is due within the time period set forth in this notice .

☐ 4. The fee submitted in this application is insufficient. A balance of $ _____ is due for presentation of excess claims (37 CFR 1.16(h)-(j) or 1.492(d)-(f)).

☐ 5. Other.

Explanation (*Provide specific details of the required correction in order to assist the applicant. Indicate whether a service charge has been added to the fee due*): _____

THE AMOUNT OF THE FEE(S) DUE IS SUBJECT TO CHANGE, GENERALLY ON OCTOBER 1 OF EACH YEAR (37 CFR 1.16, 1.21 & 1.492). THE **AMOUNT OF THE FEE(S) DUE IS DETERMINED AS OF THE DATE A COMPLETE REPLY WITH THE APPROPRIATE FEE(S) IS RECEIVED BY THE OFFICE** (37 CFR 1.8 & 1.10). BECAUSE THE AMOUNT DUE IS SUBJECT TO CHANGE, IT IS RECOMMENDED THAT APPLICANT CHECK THE CURRENT FEE SCHEDULE WHICH IS AVAILABLE ON THE USPTOS WEBSITE AT: ***http://www.uspto.gov/web/offices/ac/qs/ope/fees.htm***

Service Charges: There is a $50 service charge for processing each payment refused (including a check returned unpaid) or charged back by a financial institution (37 CFR 1.21(m)). There is a $25.00 service charge for each month when the balance of a deposit account is below $1000 at the end of the month (37 CFR 1.21(b)(2)).

Technical Support Staff (TSS): /ALLYSON PURNELL/ Phone Number: (571)272-6182

Note to TSS: Please do NOT use this notice if the application is under a final rejection.

To: uspto@rameyfirm.com,wramey@rameyfirm.com,tevenbly@rameyfirm.com
From: PAIR_eOfficeAction@uspto.gov
Cc: PAIR_eOfficeAction@uspto.gov
Subject: Private PAIR Correspondence Notification for Customer Number 63467

Oct 14, 2020 04:02:41 AM

Dear PAIR Customer:

Ramey & Schwaller, LLP
5020 Montrose Blvd.
Suite 800
Houston, TX 77006
UNITED STATES

The following USPTO patent application(s) associated with your Customer Number, 63467 , have new outgoing correspondence. This correspondence is now available for viewing in Private PAIR.

The official date of notification of the outgoing correspondence will be indicated on the form PTOL-90 accompanying the correspondence.

Disclaimer:
The list of documents shown below is provided as a courtesy and is not part of the official file wrapper. The content of the images shown in PAIR is the official record.

Application	Document	Mailroom Date	Attorney Docket No.
16552927	NFEE	10/14/2020	20160.0031.NPUS00

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 with 'e-Office Action' on the subject line or call 1-866-217-9197 during the following hours:

Monday - Friday 6:00 a.m. to 12:00 a.m.

Thank you for prompt attention to this notice,

UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT APPLICATION INFORMATION RETRIEVAL SYSTEM

Inventor: Junqing SUN	Atty. Docket No. 20160.0031.NPUS00
Application No. 16/552,927	Confirmation No.: 1683
Filing Date: August 27, 2019	Examiner: MALEK, Leila
Title: SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTER	Group Art Unit: 2632

RESPONSE TO NOTICE REQUIRING EXCESS CLAIMS FEES

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

Dear Commissioner:

Applicant acknowledges receipt of the attached Notice Requiring Excess Claims Fees dated October 14, 2020. The identified excess claim fees (total fees due of $960.00) are filed with this submission.

The reader is encouraged to contact the undersigned representative with any questions.

Respectfully submitted,

Date: December 10, 2020

/Dan Krueger/

Registration No. 42,771
Ramey & Schwaller, LLP
5020 Montrose Blvd, Suite 800
Houston, TX 77006
Tel 713-426-3923x304
uspto@rameyfirm.com
Attorney for Applicant

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
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/552,927	08/27/2019	Junqing SUN	20160.0031.NPUS00	1683

63467 7590 10/14/2020

Ramey & Schwaller, LLP
5020 Montrose Blvd.
Suite 800
Houston, TX 77006

EXAMINER	
MALEK, LEILA	

ART UNIT	PAPER NUMBER
2632	

NOTIFICATION DATE	DELIVERY MODE
10/14/2020	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):

tevenbly@rameyfirm.com
uspto@rameyfirm.com
wramey@rameyfirm.com

Marvell Semiconductor, Inc. - Ex. 1002, Page 000383

NOTICE REQUIRING EXCESS CLAIMS FEES	Application No.	Applicant(s)
	16/552,927	SUN et al.
	Art Unit	AIA (FITF) Status
	OED2	Yes

The excess claim(s) filed on 07 October 2020 is/are not accompanied by the appropriate payment of excess claims fees set forth in 37 CFR 1.16(h)-(j) or 1.492(d)-(f). Excess claims fees are required for each claim in independent form in excess of three (§ 1.16(h)), each claim (whether dependent or independent) in excess of twenty (note that § 1.75(c) indicates how multiple dependent claims are considered for fee calculation purposes) (§ 1.16(i)), and each application that contains a multiple dependent claim (§ 1.16(j)).

Since the application is not under a final rejection, applicant is given a time period of **TWO (2) MONTHS** from the mailing date of this notice to submit either: (1) the fee payment of $ 960.00 , or (2) an amendment in compliance with 37 CFR 1.121 that cancels the excess claim(s), in order to avoid ABANDONMENT. Extensions of this time period may be granted under 37 CFR 1.136, unless the excess claim(s) was/were presented in a preliminary amendment.

☐ 1. The funds in Deposit Account No. _____ are insufficient to cover the entire fee due. The balance is due within the time period set forth in this notice. See note below regarding the appropriate service charge.

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☑ 3. The amendment that includes the excess claim(s) has not been entered, since applicant has failed to remit (or authorize charge to a Deposit Account or Credit Card) the fee as indicated on the attached Patent Application Fee Determination Record (PTO/SB/06). Remittance or authorization is due within the time period set forth in this notice .

☐ 4. The fee submitted in this application is insufficient. A balance of $ _____ is due for presentation of excess claims (37 CFR 1.16(h)-(j) or 1.492(d)-(f)).

☐ 5. Other.

Explanation (*Provide specific details of the required correction in order to assist the applicant. Indicate whether a service charge has been added to the fee due*): _____

THE AMOUNT OF THE FEE(S) DUE IS SUBJECT TO CHANGE, GENERALLY ON OCTOBER 1 OF EACH YEAR (37 CFR 1.16, 1.21 & 1.492). THE **AMOUNT OF THE FEE(S) DUE IS DETERMINED AS OF THE DATE A COMPLETE REPLY WITH THE APPROPRIATE FEE(S) IS RECEIVED BY THE OFFICE** (37 CFR 1.8 & 1.10). BECAUSE THE AMOUNT DUE IS SUBJECT TO CHANGE, IT IS RECOMMENDED THAT APPLICANT CHECK THE CURRENT FEE SCHEDULE WHICH IS AVAILABLE ON THE USPTOS WEBSITE AT: ***http://www.uspto.gov/web/offices/ac/qs/ope/fees.htm***

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Technical Support Staff (TSS): /ALLYSON PURNELL/ Phone Number: (571)272-6182

Note to TSS: Please do NOT use this notice if the application is under a final rejection.

Electronic Patent Application Fee Transmittal

Application Number:	16552927
Filing Date:	27-Aug-2019
Title of Invention:	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS
First Named Inventor/Applicant Name:	Junqing SUN
Filer:	Daniel Joseph Krueger/Shanay Hines
Attorney Docket Number:	20160.0031.NPUS00

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
INDEPENDENT CLAIMS IN EXCESS OF 3	1201	2	480	960
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

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

Electronic Acknowledgement Receipt

EFS ID:	41349414
Application Number:	16552927
International Application Number:	
Confirmation Number:	1683
Title of Invention:	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS
First Named Inventor/Applicant Name:	Junqing SUN
Customer Number:	63467
Filer:	Daniel Joseph Krueger/Shanay Hines
Filer Authorized By:	Daniel Joseph Krueger
Attorney Docket Number:	20160.0031.NPUS00
Receipt Date:	10-DEC-2020
Filing Date:	27-AUG-2019
Time Stamp:	14:01:12
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$960
RAM confirmation Number	E2020B0E02329814
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	20160-0031_Response_to_add_claim_excess_fees.pdf	109244 5879cea30e8c0b8e6ef7da05de499e818033cf15	no	1
Warnings:					
Information:					
2	Transmittal Letter	2020-10-14-Notice-of-Additional-fee-16552927.pdf	93035 7cd0fc7825d4548f037681973e4bdc80307242be	no	2
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	31000 3e8a4a39ce6b170441281109c6be2374fd5a3d0c	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	233279		

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.
16/552,927	08/27/2019	Junqing SUN	20160.0031.NPUS00	1683

63467 7590 02/04/2021

Ramey & Schwaller, LLP
5020 Montrose Blvd.
Suite 800
Houston, TX 77006

EXAMINER	
MALEK, LEILA	

ART UNIT	PAPER NUMBER
2632	

NOTIFICATION DATE	DELIVERY MODE
02/04/2021	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):

tevenbly@rameyfirm.com
uspto@rameyfirm.com
wramey@rameyfirm.com

Marvell Semiconductor, Inc. - Ex. 1002, Page 000389

Office Action Summary	Application No. 16/552,927	Applicant(s) SUN et al.	
	Examiner LEILA MALEK	Art Unit 2632	AIA (FITF) Status Yes

-- 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 10/07/2020.

☐ 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) 1-4,6-9,11-13,15-19 and 21-23 is/are pending in the application.

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

6) ☑ Claim(s) 2-4,9,11-13,15-19 and 21-23 is/are allowed.

7) ☑ Claim(s) 1 and 6-8 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 08/27/2019 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: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Response to Amendment

2. This Office Action is in response to the amendments received on 10/07/2020.

Claim Rejections - 35 USC § 103

In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

3. Claims 1 and 6-8 are rejected under 35 U.S.C. 103 as being unpatentable over Kolze (US 2013/0223506), in view of Thirumoorthy (US 2010/0232493).

As to claim 1, Kolze discloses a method that comprises, in a transceiver (see paragraph 0042): determining a performance characteristic for initial pre-equalizer coefficient values (see paragraphs 0061 and 0065, Fig. 13, blocks 1310,1320, 1330, and 1340); selecting one of multiple pre-equalizer settings to specify initial pre-equalizer

coefficient values for subsequent use (see paragraphs 0075, 0077, and Fig. 13, blocks 1310 and 1320); updating the initial pre-equalizer coefficient values during a training phase (see paragraph 0079 and Fig. 13, blocks 1330, 1340, and 1350, wherein the channel monitoring phase associated with blocks 1330 and 1340 is interpreted as a training phase); and using the updated pre-equalizer coefficient values to convey a transmit data stream (see Fig. 12, blocks 1230 and 1240 and paragraph 0076). Kolze discloses all the subject matters claimed in claim 1, except that the coefficients are stored in registers. Thirumoorthy, in the same field of endeavor, discloses a transceiver in a communication system comprising an equalizer that includes an n-tap FIR filter having n coefficients (see Fig. 2, block 218 and paragraphs 0035-0036, 0054, 0062, and 0088), where the coefficients of the equalizer are stored in coefficient registers that are accessible by the equalizer (see paragraphs 0036, 0054, 0062, and 0088). It would have been obvious to one of ordinary skill in the art before the effective filing date of the invention was made to modify the teachings of Kolze as suggested by Thirumoorthy and store the coefficients of the filter (e.g., equalizer or pre-equalizer) in multiple registers in order organize and control the coefficients more effectively and independently. Athough Thirumoorthy does not expressly disclose selecting one of the registers, Kolze discloses selecting one of multiple pre-equalizer settings (e.g. coefficient values, see Fig. 13, block 1320) to specify initial pre-equalizer coefficient values and Thirumoorthy discloses saving the coefficients in different registers. One of ordinary skill in the art before the effective filing date of the invention was made would have recognized that when different coefficients (e.g. initial pre-equalizer coefficients) are stored in different registers, selecting a coefficient is equivalent to selecting the register associated with

that coefficient. Therefore, the combination of the Kolze's and Thirumoorthy's teaching covers all the limitations cited in claim 1.

As to claim 6, Kolze discloses that the performance characteristic is an error signal energy (see paragraphs 0061 and 0065, SNR is the signal energy divided by noise (error) energy).

As to claim 7, Kolze discloses that the performance characteristic is a bit error rate (see paragraph 0061, "allowable error rates" (e.g., bit error rate)). There are finite number of performance characteristics known in the art and it would have been obvious to one of ordinary skill in the art before the effective filing date of the invention was made to pick bit error rate as the performance characteristic to work with, in order to obtain predictable results and increase the performance of the communication system.

As to claim 8, Kolze discloses updating the initial pre-equalizer coefficient values (see paragraph 0079 and Fig. 13, blocks 1330, 1340, and 1350). Thirumoorthy also discloses updating the registers with the updated pre-equalizer coefficient values (see paragraph 0088 and Fig. 9, blocks 916 and 918). It would have been obvious to one of ordinary skill in the art before the effective filing date of the invention was made to modify Kolze's teaching as suggested by Thirumoorthy and update the selected register with the updated pre-equalizer coefficient values in order to make sure that the register contains the most updated version of the pre-equalizer coefficients and increase the reliability of the system.

Allowable Subject Matter

4. Claims 2-4, 9, 11-13, 15-19, and 21-23 are allowed.

Conclusion

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). 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 date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to LEILA MALEK whose telephone number is (571)272-8731. The examiner can normally be reached on Monday-Friday 8:30am-4:30pm.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chieh Fan can be reached on 571-272-3042. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may 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 https://ppair-my.uspto.gov/pair/PrivatePair. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

LEILA . MALEK
Examiner
Art Unit 2632

/LEILA MALEK/
Primary Examiner, Art Unit 2632

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/552,927	SUN et al.
	Examiner	**Art Unit**
	LEILA MALEK	2632

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

CLAIMS

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

CLAIM		DATE								
Final	Original	01/30/2021								
	1	✓								
	2	=								
	3	=								
	4	=								
	5	-								
	6	✓								
	7	✓								
	8	✓								
	9	=								
	10	-								
	11	=								
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	20	-								
	21	=								
	22	=								
	23	=								

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/552,927	SUN et al.
	Examiner	Art Unit
	LEILA MALEK	2632

CPC - Searched*		
Symbol	Date	Examiner

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
EAST, IEEE, Inventor Name Search	01/30/2021	L.M.

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

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PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L10	49	("10212260"|"20130343400"|"20140086264"|"20140146833"|"20150003505"|"20160337114"|"20200076651"|"8301036"|"9071479"|"9385859"|"9935800").PN.	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 11:29 AM
L11	11	("10212260"|"20130343400"|"20140086264"|"20140146833"|"20150003505"|"20160337114"|"20200076651"|"8301036"|"9071479"|"9385859"|"9935800").PN.	US-PGPUB; USPAT	OR	ON	ON	2020/06/22 12:04 PM
L12	11	("10212260"|"20130343400"|"20140086264"|"20140146833"|"20150003505"|"20160337114"|"20200076651"|"8301036"|"9071479"|"9385859"|"9935800").PN.	US-PGPUB; USPAT	OR	ON	ON	2020/06/22 12:15 PM
L13	2	12 AND (pre$1equaliz$3 near3 coefficient$1)	US-PGPUB; USPAT	OR	ON	ON	2020/06/22 12:15 PM
L14	2	12 AND (pre$1equaliz$3 near3 (tap$1 OR weight$1 OR coefficient$1))	US-PGPUB; USPAT	OR	ON	ON	2020/06/22 12:16 PM
L15	0	(select$3 OR pick$3 OR obtain$3 OR choos$3) near2 (set OR group) near3 (pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 12:21 PM
L16	91	(select$3 OR pick$3 OR obtain$3 OR choos$3) near4 (pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 12:21 PM
L17	1	16 AND c2m	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:07 PM

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L18	1	(select$3 OR pick$3 OR obtain$3 OR choos$3) near4 (pre$1equaliz$3) AND c2m	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:08 PM
L19	1	(pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1) AND c2m	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:09 PM
L20	1	(pre$1equaliz$3) AND c2m adj1 (channels OR path$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:10 PM
L21	2	(pre$1equaliz$3) AND c2m	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:10 PM
L22	230	(pre$1equaliz$3) AND (channel adj1 models)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:48 PM
L23	44	(pre$1equaliz$3) WITH (channel adj1 models)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:49 PM
L24	0	23 AND (different OR multiple OR plurality) adj2 (channel adj1 models)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:51 PM
L25	3	(pre$1equaliz$3) WITH (channel adj1 models)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	ON	2020/06/22 04:54 PM
L26	8	(pre$1equaliz$3 near3 (coefficient$1 OR tap$1 OR weight$1)) WITH (channel adj1 model$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 04:56 PM
L27	44	(pre$1equaliz$3) WITH (channel adj1 model$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/22 05:24 PM
L28	1	serdes AND c2m AND pre$1equaliz$3	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 10:09 AM
L29	1	serdes AND c2m near3	US-PGPUB; USPAT;	OR	ON	ON	2020/06/23

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		channel$1	USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB				10:10 AM
L30	12	serdes AND c2m	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 10:10 AM
L31	6	serdes AND c2m AND (coefficient$1 OR weight$1 OR tap$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 11:32 AM
L32	0	serdes AND c2c AND pre$1equaliz$3	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 11:37 AM
L33	45	serdes AND pre$1equaliz$3	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 11:37 AM
L34	13	serdes AND pre$1equaliz$3 AND ((select$3 OR choos$3 OR pick$3 OR determin$3) near7 pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 11:38 AM
L35	524	(channel near2 response) near6 (channel adj1 model)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 11:42 AM
L36	10	pre$1equaliz$3 SAME (coefficient$1 OR tap$1 OR weight$1) SAME (channel adj1 model$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 11:45 AM
L37	4	(select$3 OR choos$3 OR pick$3 OR determin$3) near5 pre$1equaliz$3 SAME (channel adj1 model$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 11:48 AM
L38	0	(select$3 OR choos$3 OR pick$3 OR determin$3) near4 (register OR memory OR storage) SAME (pre$1equaliz4)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 03:17 PM
L39	43	(select$3 OR choos$3 OR pick$3 OR determin$3) near4 (register OR	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO;	OR	ON	ON	2020/06/23 03:17 PM

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		memory OR storage) SAME (pre$1equaliz$3)	DERWENT; IBM_TDB				
L40	6	(select$3 OR choos$3 OR pick$3 OR determin$3) near4 (table) SAME (pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 03:52 PM
L41	9	(select$3 OR pick$3 OR obtain$3 OR choos$3 OR determin$3 OR decid$3) near2 (set OR group OR table) near3 (coefficient$1 OR tap$1 OR weight$1) SAME pre$1equaliz$3	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 05:09 PM
L42	2	updat$3 near4 (coefficient$1 OR tap$1 OR weight$1) near4 (pre$1equaliz$3) WITH (training adj1 (mode OR phase OR period))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 05:49 PM
L43	8	updat$3 near4 (coefficient$1 OR tap$1 OR weight$1) near4 (pre$1equaliz$3) WITH (training)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/23 05:50 PM
L44	3	updat$3 near4 (coefficient$1 OR tap$1 OR weight$1) near4 (pre$1equaliz$3) WITH (initializ$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 01:56 PM
L45	119	(select$3 OR pick$3 OR obtain$3 OR choos$3) near2 (set OR group OR table OR register) near3 (pre$1distort$3) near3 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 02:46 PM
L46	0	(select$3 OR pick$3 OR obtain$3 OR choos$3) near2 (set OR group OR table OR register) near3 (pre$1distort$3) near3 (coefficient$1 OR tap$1 OR weight$1) SAME (channel adj1 model)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 02:49 PM
L47	2	(select$3 OR pick$3 OR obtain$3 OR choos$3) near2 (set OR group OR table OR register) near3	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 02:49 PM

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		(pre$1distort$3) near3 (coefficient$1 OR tap$1 OR weight$1) AND (channel adj1 model)					
L48	4115	(sav$3 OR stor$3) near4 (coefficient$1 OR tap$1 OR weight$1) near3 (different OR independent OR plurality OR several) near3 (register$1 OR table$1 OR memor$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 03:12 PM
L49	17	(sav$3 OR stor$3) near4 (equalizer OR pre$1equalizer) near2 (coefficient$1 OR tap$1 OR weight$1) near3 (different OR independent OR plurality OR several OR multiple) near3 (register$1 OR memor$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 03:14 PM
L50	51	(registers OR memories OR (memory adj1 units)) near4 (equalizer OR pre$1equalizer) near2 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	ON	2020/06/24 03:19 PM
L51	4	(registers OR memories OR (memory adj1 units)) near4 (pre$1equaliz$5) near2 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	ON	2020/06/24 03:50 PM
L52	11	(select$3 OR choos$3 OR pick$3) near3 (pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 04:18 PM
L53	2	(select$3 OR choos$3 OR pick$3) near5(initial) near4 (pre$1equaliz$3) near5 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 04:22 PM
L54	29	(select$3 OR choos$3 OR pick$3) near4 (pre$1equaliz$3) near5 (coefficient$1 OR tap$1 OR weight$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 04:28 PM
L55	23	54 AND (updat$3 OR adjust$3) near5	US-PGPUB; USPAT; USOCR; FIT (CN, FR,	OR	ON	ON	2020/06/24 04:31 PM

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		(coefficient$1 OR tap$1 OR weight$1)	WO); FPRS; EPO; JPO; DERWENT; IBM_TDB				
L56	8	(coefficient$1 OR tap$1 OR weight$1) near6 pre$1equaliz$3 WITH (channel adj1 model)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:09 PM
L57	31	(coefficient$1 OR tap$1 OR weight$1) near6 pre$1equaliz$3 WITH (impulse adj1 response adj3 channel)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:13 PM
L58	39	(coefficient$1 OR tap$1 OR weight$1) near6 pre$1equaliz$3 WITH ((impulse adj1 response adj3 channel) OR (channel adj1 model))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:15 PM
L59	0	L58 AND (EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 ((channel adj1 impulse) OR (channel adj1 model))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:17 PM
L60	215	(coefficient$1 OR tap$1 OR weight$1) WITH (EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 ((channel adj1 impulse) OR (channel adj1 model))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:18 PM
L61	0	(coefficient$1 OR tap$1 OR weight$1) WITH (EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 ((channel adj1 impulse) OR (channel adj1 model)) AND (pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:18 PM
L62	66	(coefficient$1 OR tap$1 OR weight$1) WITH ((EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 channel) AND (pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:19 PM

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L63	11	(coefficient$1 OR tap$1 OR weight$1) WITH ((EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 channel) AND ((pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:19 PM
L64	8	(coefficient$1 OR tap$1 OR weight$1) WITH (channel adj1 model) AND ((pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:24 PM
L65	1	c2m AND (insertion adj1 loss) AND (package adj1 loss)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:30 PM
L66	2	((coefficient$1 OR tap$1 OR weight$1) near3 pre$1equaliz$3) WITH ((performance adj1 characteristic$1) OR (error adj1 signal adj1 (power OR energy)) OR (bit adj1 error adj1 rate))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:36 PM
L67	0	(sav$3 OR stor$3) near3 (updated OR adjusted) adj3 (coefficient$1 OR tap$1 OR weight$1) near3 pre$1equaliz$3	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:41 PM
L68	30	(sav$3 OR stor$3) near3 (updated OR adjusted) adj3 (coefficient$1 OR tap$1 OR weight$1) near3 equaliz$3	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:41 PM
L69	11	(port adj1 connector) WITH transceiver WITH pluggable	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:49 PM
L70	2	(port adj1 connector) WITH transceiver WITH pluggable AND pre$1equalizer$1	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:49 PM
L71	2	(port adj1 connector) WITH transceiver WITH pluggable AND	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO;	OR	ON	ON	2020/06/24 06:49 PM

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		pre$1equaliz$3	DERWENT; IBM_TDB				
L72	0	(chip$1to$1module OR c2m) AND (port adj1 connect$3) AND (plug$4 near3 transceiver)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:50 PM
L73	364	(port adj1 connect$3) AND (plug$4 near3 transceiver)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/24 06:51 PM
L74	13	(port adj1 connect$3) WITH (plug$4 near3 transceiver)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:23 AM
L75	3	(port adj1 connect$3) WITH (plug$4 near3 transceiver) AND (filter OR pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:23 AM
L76	13	(port adj1 connect$3) WITH (plug$4 near3 transceiver)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:27 AM
L77	319	(port near2 connect$3) WITH (plug$5 near3 transceiver)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:32 AM
L78	3	(port near2 connect$3) WITH (plug$5 near3 transceiver) WITH (port adj1 transceiver)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:33 AM
L79	2	(pre$1equaliz$3) near3 (coefficients OR taps OR weights OR (coefficient adj1 values) OR (tap adj1 values)) near5 (registers OR (storage adj1 units) OR memories)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	ON	2020/06/25 06:35 AM
L80	4	(pre$1equaliz$3) SAME (coefficients OR taps OR weights OR (coefficient adj1 values) OR (tap adj1 values)) near6 (registers OR (storage adj1 units) OR memories)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	ON	2020/06/25 06:36 AM
L81	1	(pre$1equaliz$3) SAME ((coefficient OR tap OR weight) near2 set) near6	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO;	OR	OFF	ON	2020/06/25 06:46 AM

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		(register$1 OR (storage adj1 unit$1) ormemor$3)	DERWENT; IBM_TDB				
L82	9	(pre$1equaliz$3) SAME ((coefficient OR tap OR weight) near2 set) near6 (register$1 OR (storage adj1 unit$1) OR memor$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:47 AM
L83	0	(pre$1equaliz$3) SAME (sav$3 OR stor$3) near3 (each OR different OR several OR multiple) adj1 set$1 near3 (coefficient OR tap OR weight)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:51 AM
L84	15	(pre$1equaliz$3) SAME (each OR different OR several OR multiple) adj1 set$1 near3 (coefficient OR tap OR weight)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 06:52 AM
L85	0	(pre$1equaliz$3) SAME (port adj1 transmitter)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 10:21 AM
L86	0	(pre$1equaliz$3) SAME3 (port adj1 transmitter)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 10:21 AM
L87	0	(pre$1equaliz$3) AND (port adj1 transmitter)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 10:22 AM
L88	22	(pre$1equaliz$3) AND (port near2 transmitter)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 10:22 AM
L89	55	(pre$1equaliz$3) AND (port near2 transmit$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 10:24 AM
L90	12	(pre$1equaliz$3) AND (port near2 transceiv$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:24 AM
L91	14	(pre$1equaliz$3) AND (port near3 transceiv$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO;	OR	ON	ON	2020/06/25 11:27 AM

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			DERWENT; IBM_TDB				
L92	3177	cable SAME (port near3 transceiv$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:40 AM
L93	1601	cable WITH (port near3 transceiv$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:40 AM
L94	2460	network WITH (port near1 transceiv$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:41 AM
L95	1497	network WITH (port adj1 transceiv$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:41 AM
L96	609	network near5(port adj1 transceiv$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:41 AM
L97	0	network near5 "port adj1 transceiv$3"	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:43 AM
L98	0	"port adj1 transceiv$3"	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:43 AM
L99	0	"port adj1 transceiver"	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:44 AM
L100	4775	"port transceiver"	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:44 AM
L101	550	"port transceiver" near5 network	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/06/25 11:45 AM
L102	483	"port transceiver" near5 network	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	ON	2020/06/25 11:45 AM

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L103	1	(select$3 near4 register) WITH pre$1equaliz$3 AND (sun.inv. OR qian.inv.)	US-PGPUB; USPAT	OR	ON	ON	2020/07/03 06:52 AM
L104	1	"20020141347" AND (model WITH coefficient$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 03:32 PM
L105	1	"20020141347" AND (model WITH (coefficient$1 OR tap$1 OR weight$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 03:36 PM
L106	160	(channel adj1 model) near4 (channel adj1 characteristic$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 03:42 PM
L107	7	(channel adj1 model) WITH (pre$1equalizer near3 (tap$1 OR coefficient$1 OR weight$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 04:01 PM
L108	1	"20130223506" AND (pre$1equaliz$3 WITH (fir OR filter$3))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 10:52 PM
L109	839852	20100232493and (control$4 near5 (coefficient$1 OR tap$1 OR register$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 11:14 PM
L110	0	"20100232493" AND (control$4 near5 (coefficient$1 OR tap$1 OR register$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 11:17 PM
L111	2	"20100232493" AND (control$4 WITH (coefficient$1 OR tap$1 OR register$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 11:17 PM
L112	2	"20100232493" AND (control$4 WITH (coefficient$1 OR tap$1 OR register$1)) AND (register WITH coefficient$1)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/03 11:18 PM
L113	1	"20130201316" AND (connector WITH port)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO;	OR	ON	ON	2020/07/04 08:44 AM

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			DERWENT; IBM_TDB				
L114	1	"20130201316" AND (connector SAME port)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/04 08:46 AM
L115	2	"20130201316" AND (plug$4 SAME (modem OR transceiver))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2020/07/04 09:03 AM
L116	22	((performance adj1 characteristic$1) OR (snr OR snir OR ber) OR (signal adj2 noise adj2 ratio) OR (bit adj1 error adj1 rate) OR (error adj1 signal adj1 energy)) WITH (pre$1equaliz$3 near2 (coefficient$1 OR tap$1 OR weight$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/04 04:40 PM
L117	6	(ber OR (bit adj1 error adj1 rate)) WITH (pre$1equaliz$3 near2 (coefficient$1 OR tap$1 OR weight$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/04 05:30 PM
L118	3	(ber OR (bit adj1 error adj1 rate)) SAME ((choos$3 OR select$3 OR pick$3 OR updat$3 OR adapt$3 OR determin$3 OR calculat$3) near3 pre$1equaliz$3 near2 (coefficient$1 OR tap$1 OR weight$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/05 10:30 AM
L119	35	(ber OR (bit adj1 error adj1 rate)) AND ((choos$3 OR select$3 OR pick$3 OR updat$3 OR adapt$3 OR determin$3 OR calculat$3) near3 pre$1equaliz$3 near2 (coefficient$1 OR tap$1 OR weight$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/05 10:31 AM
L120	93	(ber OR (bit adj1 error adj1 rate)) AND (pre$1equaliz$3 near2 (coefficient$1 OR tap$1 OR weight$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/05 03:22 PM

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L121	1	(ber OR (bit adj1 error adj1 rate)) SAME (pre$1equaliz$3 near2 (parameter$1 OR setting$1))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/05 09:20 PM
L122	28	(ber OR (bit adj1 error adj1 rate)) WITH (pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/05 09:22 PM
L123	58	(ber OR (bit adj1 error adj1 rate)) SAME (pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/05 09:31 PM
L124	1	"20130223506" AND (different near4 channel$1 WITH pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/16 04:07 PM
L125	17	((different OR each) adj1 (set$1 OR group$1)) near4(equaliz$3 OR pre$1equaliz$3) near4 (coefficients OR weights OR taps) WITH (stor$3 OR storage OR ram OR table OR memory)	US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/16 04:19 PM
L126	1	"20130223506" AND ((different OR distinct OR each) near7 channel$1 WITH pre$1equaliz$3)	US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/16 04:41 PM
L127	6535	((set$1 OR group$1)) near4(equaliz$3 OR pre$1equaliz$3 OR filter) near4 (coefficient$1 OR weight$1 OR tap$1) near8 (register OR storage OR ram OR table OR memory)	US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/19 10:51 AM
L132	14	((each OR every OR different) adj2 (set$1 OR group$1)) near4(equaliz$3 OR pre$1equaliz$3 OR filter$1) near4 (coefficient$1 OR	US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/19 02:42 PM

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		weight$1 OR tap$1) near8 (separate OR different OR distinct) adj1 (register OR storage OR ram OR table OR memory) AND @ad<=20180828					
L133	2	"20130223506" AND (channel$1 WITH (pre$1equaliz$3 OR equaliz$3))	US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/19 03:30 PM
L134	2	"20130223506" AND (channel$1 near5 characteristic$1)	US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/19 04:42 PM
L135	2	"20130223506" AND (snr)	US-PGPUB; USPAT; USOCR; FIT (AP, AT, AU, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/19 04:42 PM
L136	6	((select$3 OR choos$3 OR pick$3) near4 beam near2 pair) WITH (interfer$3 near4 (enb OR station$1 OR ue$1 OR device$1 OR unit$1))	US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/01/21 01:24 PM
L137	0	"20130201316" AND (port WITH equaliz$3)	US-PGPUB; USPAT	OR	ON	ON	2021/01/30 05:44 PM

PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.

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To: uspto@rameyfirm.com,wramey@rameyfirm.com,tevenbly@rameyfirm.com
From: PAIR_eOfficeAction@uspto.gov
Cc: PAIR_eOfficeAction@uspto.gov
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Dear PAIR Customer:

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Application	Document	Mailroom Date	Attorney Docket No.
16552927	CTFR	02/04/2021	20160.0031.NPUS00

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UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT APPLICATION INFORMATION RETRIEVAL SYSTEM

Serial No.:	16/552927
Filing Date:	2019-08-27
Confirmation:	1683
Atty Docket:	20160.0031.NPUS00
1st Inventor:	Junqing Sun
Title:	SerDes Pre-equalizer having Adaptable Preset Coefficient Registers
Examiner:	Leila Malek
Art Unit:	2632

REPLY TO FINAL OFFICE ACTION OF 2021-02-04

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 23313-1450

Dear Sir or Madam:

This paper is submitted in response to the above-identified office action. Please reconsider the rejections in light of the following amendments and remarks.

An Amendment to the Claims begins on page 2.

Remarks begin on page 5.

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Amendment to the Claims

Please amend the claims to read as provided below:

1. (Canceled)

2. (Previously presented) A SerDes communications method that comprises, in a transceiver:

selecting one of multiple registers to specify initial pre-equalizer coefficient values, each of the multiple registers corresponding to a different channel model;

updating the initial pre-equalizer coefficient values during a training phase; and

using the updated pre-equalizer coefficient values to convey a transmit data stream.

3. (Original) The method of claim 2, wherein at least some of the different channel models are for chip-to-module (C2M) channels with different insertion loss and package loss characteristics.

4. (Original) The method of claim 2, wherein at least some of the different channel models presume different types of receiver equalization.

5. (Currently amended) The method of ~~claim 1~~ claim 2, wherein said selecting includes using the initial pre-equalizer coefficient values to determine a performance characteristic for each of the multiple registers.

6. (Currently amended) The method of ~~claim 1~~ claim 5, wherein the performance characteristic is an error signal energy.

7. (Currently amended) The method of ~~claim 1~~ claim 5, wherein the performance characteristic is a bit error rate.

8. (Currently amended) The method of ~~claim 1~~ claim 5, further comprising updating the selected register with the updated pre-equalizer coefficient values.

9. (Previously presented) A chip-to-module communications link that comprises a port connector coupling a port transceiver to a pluggable module transceiver, the pluggable module transceiver including:

one or more transmit filters to each pre-equalize a corresponding serial symbol stream being transmitted to the port transceiver; and

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a controller having multiple registers, each of the multiple registers containing a set of initial coefficient values corresponding to a different channel model, the controller using one of the registers to set initial coefficient values for the one or more transmit filters.

10. (Canceled)

11. (Previously presented) A chip-to-module communications link that comprises a port connector coupling a port transceiver to a pluggable module transceiver, the pluggable module transceiver including:

one or more transmit filters to each pre-equalize a corresponding serial symbol stream being transmitted to the port transceiver; and

a controller having multiple registers, each of the multiple registers containing a set of initial coefficient values for which the port transceiver determines a performance characteristic,

the controller using one of the registers selected by the port transceiver to specify the initial coefficient values for the one or more transmit filters.

12. (Original) The communications link of claim 11, wherein the performance characteristic is an error signal energy.

13. (Original) The communications link of claim 11, wherein the performance characteristic is a bit error rate.

14. (Canceled)

15. (Previously presented) The communications link of claim 9, wherein at least some of the different channel models are for chip-to-module (C2M) channels with different insertion loss and package loss characteristics.

16. (Previously presented) The communications link of claim 9, wherein at least some of the different channel models presume different types of receiver equalization.

17. (Previously presented) The communications link of claim 11, wherein the port transceiver generates updates for the coefficient values of the one or more transmit filters.

18. (Original) The communications link of claim 17, wherein the controller saves

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updated coefficient values in one of the registers.

19. (Previously presented) A pluggable module transceiver including:

one or more transmit filters to each pre-equalize a corresponding serial symbol stream being transmitted to a port transceiver; and

a controller having multiple registers, each of the multiple registers containing a set of initial coefficient values corresponding to a different channel model, the controller using one of the registers to set initial coefficient values for the one or more transmit filters.

20. (Canceled)

21. (Previously presented) The pluggable module transceiver of claim 19, wherein the port transceiver determines a performance characteristic for each register.

22. (Previously presented) The pluggable module transceiver of claim 21, wherein the performance characteristic is an error signal energy.

23. (Previously presented) The pluggable module transceiver of claim 21, wherein the performance characteristic is a bit error rate.

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Remarks

Status of the Claims

Claims 1-4, 6-9, 11-13, 15-19, and 21-23 were pending. Claim 1 is canceled. Original claim 5 is re-introduced with a new dependency. Claims 6-8 are amended to alter their dependency from canceled claim 1. Claims 2-9, 11-13, 15-19, and 21-23 are now pending.

Rejections Under 35 USC § 103

Claims 1 and 6-8 stand rejected under 35 USC § 103 as being unpatentable over US2013/0223506 ("Kolze") in view of US2010/0232493 ("Thirumoorthy"). Claim 1 is canceled herein, and the dependencies of claims 6-8 are herein amended such that claims 6-8 now depend (indirectly) from allowed claim 2. Claims 6-8 are believed to be in condition for allowance for at least this reason.

Allowable Subject Matter

Claims 2-4, 9, 11-13, 15-19, and 21-23 stand allowed.

Previously canceled claim 5 is re-introduced with a new dependency from independent claim 2, and is believed allowable for at least this reason. Claims 6-8 now depend from claim 5 and are similarly believed allowable at least due to their dependence from claim 2.

All claims are believed to be in condition for allowance.

Conclusion

Applicant appreciates the examiner's careful examination of the present application. The examiner is encouraged to contact the undersigned practitioner if an interview might prove helpful to the examination process.

Respectfully submitted,

/Dan Krueger/ 2021-03-16

_____ _____

Daniel J. Krueger Date
Reg. No. 42,771
(713) 449-9669
Attorney for Applicant

Ramey & Schwaller LLP

Marvell Semiconductor, Inc. - Ex. 1002, Page 000417

5020 Montrose Blvd # 800
Houston TX 77006
713-426-3923 x304

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Electronic Acknowledgement Receipt

EFS ID:	42189968
Application Number:	16552927
International Application Number:	
Confirmation Number:	1683
Title of Invention:	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS
First Named Inventor/Applicant Name:	Junqing SUN
Customer Number:	63467
Filer:	Daniel Joseph Krueger/Shanay Hines
Filer Authorized By:	Daniel Joseph Krueger
Attorney Docket Number:	20160.0031.NPUS00
Receipt Date:	16-MAR-2021
Filing Date:	27-AUG-2019
Time Stamp:	10:44:39
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		C031RTF.pdf	130827 70fa1c824fdde1ea0323059d756780dd06dabb18	yes	6

	Multipart Description/PDF files in .zip description		
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	Amendment Copy Claims/Response to Suggested Claims	2	4
	Applicant Arguments/Remarks Made in an Amendment	5	6
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New Applications Under 35 U.S.C. 111

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

National Stage of an International Application under 35 U.S.C. 371

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

New International Application Filed with the USPTO as a Receiving Office

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

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. 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 displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 16/552,927	Filing Date 08/27/2019	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $100 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $460 =	
☐ 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).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	03/16/2021	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 19	Minus	** 20	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 4	Minus	*** 5	= 0		x $480 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	SLIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/JULIET MCMILLAN/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

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

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

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

NOTICE OF ALLOWANCE AND FEE(S) DUE

63467 7590 03/31/2021

Ramey & Schwaller, LLP
5020 Montrose Blvd.
Suite 800
Houston, TX 77006

EXAMINER	
MALEK, LEILA	
ART UNIT	PAPER NUMBER
2632	

DATE MAILED: 03/31/2021

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/552,927	08/27/2019	Junqing SUN	20160.0031.NPUS00	1683

TITLE OF INVENTION: SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1200	$0.00	$0.00	$1200	06/30/2021

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: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

Marvell Semiconductor, Inc. - Ex. 1002, Page 000422

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (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)

63467 7590 03/31/2021

Ramey & Schwaller, LLP
5020 Montrose Blvd.
Suite 800
Houston, TX 77006

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 transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/552,927	08/27/2019	Junqing SUN	20160.0031.NPUS00	1683

TITLE OF INVENTION: SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1200	$0.00	$0.00	$1200	06/30/2021

EXAMINER	ART UNIT	CLASS-SUBCLASS
MALEK, LEILA	2632	375-219000

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 03-09 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 must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). 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. Fees submitted: ❑Issue Fee ❑Publication Fee (if required) ❑Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

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.
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.
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. _____

Marvell Semiconductor, Inc. - Ex. 1002, Page 000423

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.
16/552,927	08/27/2019	Junqing SUN	20160.0031.NPUS00	1683

63467 7590 03/31/2021

Ramey & Schwaller, LLP
5020 Montrose Blvd.
Suite 800
Houston, TX 77006

EXAMINER	
MALEK, LEILA	
ART UNIT	PAPER NUMBER
2632	

DATE MAILED: 03/31/2021

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

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

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.

Marvell Semiconductor, Inc. - Ex. 1002, Page 000424

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 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, 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. 16/552,927	Applicant(s) SUN et al.	
	Examiner LEILA MALEK	Art Unit 2632	AIA (FITF) Status Yes

-- 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 03/16/2021.
   ☐ 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 2-9,11-13,15-19 and 21-23 . 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 _____.
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 _____.

/LEILA MALEK/
Primary Examiner, Art Unit 2632

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/552,927	SUN et al.
	Examiner	**Art Unit**
	LEILA MALEK	2632

CPC						
Symbol					**Type**	**Version**
H04L	/	25	/	03019	F	2013-01-01
H04L	/	7	/	0087	I	2013-01-01
G06N	/	20	/	00	I	2019-01-01
H04B	/	1	/	40	I	2013-01-01
H04L	/	2025	/	03808	A	2013-01-01

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

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	19	
/LEILA MALEK/ Primary Examiner, Art Unit 2632	25 March 2021	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

U.S. Patent and Trademark Office — Part of Paper No.: 20210325

Marvell Semiconductor, Inc. - Ex. 1002, Page 000427

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/552,927	SUN et al.
	Examiner	**Art Unit**
	LEILA MALEK	2632

INTERNATIONAL CLASSIFICATION				
CLAIMED				
H04L	/	25	/	03

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**
375	219

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					
375	219					

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 19	
/LEILA MALEK/ Primary Examiner, Art Unit 2632 (Primary Examiner)	25 March 2021 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

U.S. Patent and Trademark Office — Part of Paper No.: 20210325

Marvell Semiconductor, Inc. - Ex. 1002, Page 000428

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/552,927	SUN et al.
	Examiner	**Art Unit**
	LEILA MALEK	2632

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

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
-	1	-	10	16	19										
1	2	11	11	-	20										
2	3	12	12	17	21										
3	4	13	13	18	22										
4	5	-	14	19	23										
5	6	9	15												
6	7	10	16												
7	8	14	17												
8	9	15	18												

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	19	
/LEILA MALEK/ Primary Examiner, Art Unit 2632	25 March 2021	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

U.S. Patent and Trademark Office — Part of Paper No.: 20210325

Marvell Semiconductor, Inc. - Ex. 1002, Page 000429

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/552,927	SUN et al.
	Examiner	Art Unit
	LEILA MALEK	2632

CPC - Searched*		
Symbol	Date	Examiner
H04L25/03019, H04L7/0087, G06N20/00, H04B1/40, H04L27/01, H04L25/03885	03/25/2021	L.M.

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner
375	219	03/25/2021	L.M.

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
EAST, IEEE, Inventor Name Search, IP.com	03/25/2021	L.M.
H04L25/03019, H04L7/0087, G06N20/00, H04B1/40, H04L27/01, H04L25/03885	03/25/2021	L.M.

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
375	219	03/25/2021	L.M.

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OK TO ENTER: /L.M/

20160.0031

Serial No.:	16/552927
Filing Date:	2019-08-27
Confirmation:	1683
Atty Docket:	20160.0031.NPUS00
1st Inventor:	Junqing Sun
Title:	SerDes Pre-equalizer having Adaptable Preset Coefficient Registers
Examiner:	Leila Malek
Art Unit:	2632

REPLY TO FINAL OFFICE ACTION OF 2021-02-04

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 23313-1450

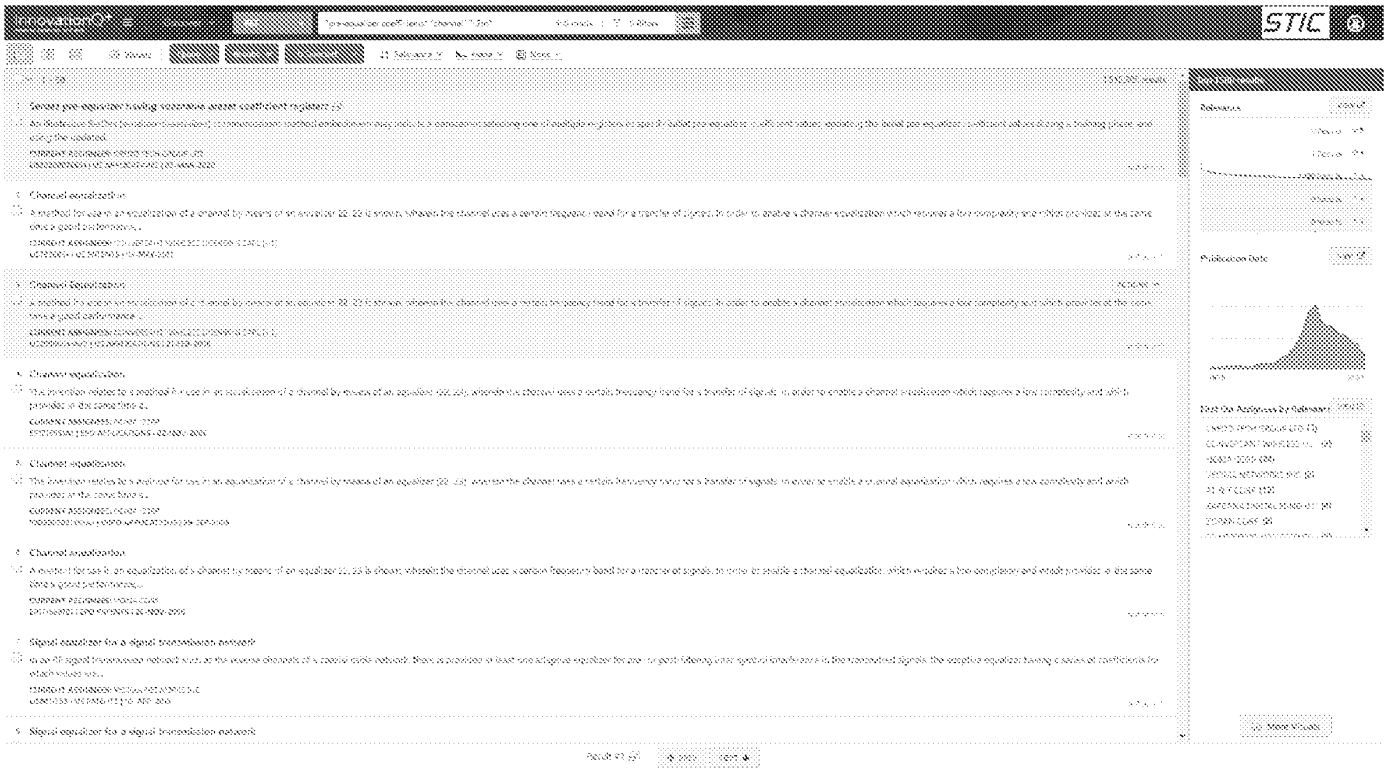
Dear Sir or Madam:

This paper is submitted in response to the above-identified office action. Please reconsider the rejections in light of the following amendments and remarks.

An Amendment to the Claims begins on page 2.

Remarks begin on page 5.

Marvell Semiconductor, Inc. - Ex. 1002, Page 000431



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Search History

Mar 25, 2021, 12:10:49 PM

Set #	Search Query	Details Results | Date & Time
55	("Full Text & Metadata":pre-equalizer coefficients) AND ("Full Text & Metadata":register) AND ("Full Text & Metadata":channel model)	23 | Mar 25, 2021, 12:10:09 PM
54	("Full Text & Metadata":chip-to-module) AND ("Full Text & Metadata":pre-equalizer) AND ("Full Text & Metadata":channel model)	6 | Mar 25, 2021, 12:09:13 PM
53	("Full Text & Metadata":chip-$1to$1module) AND ("Full Text & Metadata":pre-equalizer) AND ("Full Text & Metadata":channel model)	0 | Mar 25, 2021, 12:08:25 PM
52	("Full Text & Metadata":"ofdm") AND ("Full Text & Metadata":"qam") AND ("Full Text & Metadata":"bpsk")	138 | Mar 24, 2021, 10:58:07 AM
51	("Full Text & Metadata":phase adjusting the equalizing clock) AND ("Full Text & Metadata":data sampler) AND ("Full Text & Metadata":quality)	133 | Mar 12, 2021, 12:24:33 PM
50	"mimo bf setup frame"	2 | Mar 3, 2021, 4:07:38 PM
49	"mimo bf setup frame"	2 | Mar 3, 2021, 4:06:29 PM
48	"lxss-req-reciprocal subfield"	0 | Mar 3, 2021, 10:48:34 AM
47	"mimo bf setup frame"	2 | Mar 3, 2021, 10:40:16 AM
46	"mimo bf setup frame"	2 | Mar 3, 2021, 10:27:00 AM
45	"mimo bf setup frame"	2 | Mar 3, 2021, 10:25:57 AM
44	"mimo bf setup frame"	2 | Mar 3, 2021, 10:11:46 AM
43	("Full Text & Metadata":"auto-zero") AND ("Full Text & Metadata":multiplexer) AND ("Full Text & Metadata":decision feedback equalizer)	0 | Feb 27, 2021, 10:06:00 AM
42	("Full Text & Metadata":auto-zero) AND ("Full Text & Metadata":decision feedback equalizer)	29 | Feb 27, 2021, 10:05:27 AM
41	("Full Text & Metadata":half-cell) AND ("Full Text & Metadata":auto-zero)	4 | Feb 27, 2021, 10:04:30 AM
40	("Full Text & Metadata":half-cell) AND ("Full Text & Metadata":auto-zero) AND	0 | Feb 27, 2021, 10:04:09 AM

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PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L10	49	("10212260"|"20130343400"|"20140086264"|"20140146833"|"20150003505"|"20160337114"|"20200076651"|"8301036"|"9071479"|"9385859"|"9935800").PN.	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/22 11:06 AM
L11	11	("10212260"|"20130343400"|"20140086264"|"20140146833"|"20150003505"|"20160337114"|"20200076651"|"8301036"|"9071479"|"9385859"|"9935800").PN.	(US-PGPUB ; USPAT)	OR	ON	ON	2020/06/22 12:06 PM
L12	11	("10212260"|"20130343400"|"20140086264"|"20140146833"|"20150003505"|"20160337114"|"20200076651"|"8301036"|"9071479"|"9385859"|"9935800").PN.	(US-PGPUB ; USPAT)	OR	ON	ON	2020/06/22 12:06 PM
L13	2	12 AND (pre$1equaliz$3 near3 coefficient$1)	(US-PGPUB ; USPAT)	OR	ON	ON	2020/06/22 12:06 PM
L14	2	12 AND (pre$1equaliz$3 near3 (tap$1 OR weight$1 OR coefficient$1))	(US-PGPUB ; USPAT)	OR	ON	ON	2020/06/22 12:06 PM
L15	0	(select$3 OR pick$3 OR obtain$3 OR choos$3) near2 (set OR group) near3 (pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/22 12:06 PM
L16	91	(select$3 OR pick$3 OR obtain$3 OR choos$3) near4 (pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/22 12:06 PM
L17	1	16 AND c2m	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/22 04:06 PM
L18	1	(select$3 OR pick$3 OR obtain$3 OR choos$3) near4 (pre$1equaliz$3) AND c2m	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/22 04:06 PM
L19	1	(pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1) AND c2m	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/22 04:06 PM
L20	1	(pre$1equaliz$3) AND c2m adj1 (channels OR path$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/22 04:06 PM

L21	2	(pre$1equaliz$3) AND c2m	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/22 04:06 PM
L22	230	(pre$1equaliz$3) AND (channel adj1 models)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/22 04:06 PM
L23	44	(pre$1equaliz$3) WITH (channel adj1 models)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/22 04:06 PM
L24	0	23 AND (different OR multiple OR plurality) adj2 (channel adj1 models)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/22 04:06 PM
L25	3	(pre$1equaliz$3) WITH (channel adj1 models)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	OFF	ON	2020/06/22 04:06 PM
L26	8	(pre$1equaliz$3 near3 (coefficient$1 OR tap$1 OR weight$1)) WITH (channel adj1 model$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/22 04:06 PM
L27	44	(pre$1equaliz$3) WITH (channel adj1 model$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/22 05:06 PM
L28	1	serdes AND c2m AND pre$1equaliz$3	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 10:06 AM
L29	1	serdes AND c2m near3 channel$1	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 10:06 AM
L30	12	serdes AND c2m	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 10:06 AM
L31	6	serdes AND c2m AND (coefficient$1 OR weight$1 OR tap$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 11:06 AM
L32	0	serdes AND c2c AND pre$1equaliz$3	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 11:06 AM
L33	45	serdes AND pre$1equaliz$3	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 11:06 AM

L34	13	serdes AND pre$1equaliz$3 AND ((select$3 OR choos$3 OR pick$3 OR determin$3) near7 pre$1equaliz$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 11:06 AM
L35	524	(channel near2 response) near6 (channel adj1 model)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 11:06 AM
L36	10	pre$1equaliz$3 SAME (coefficient$1 OR tap$1 OR weight$1) SAME (channel adj1 model$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 11:06 AM
L37	4	(select$3 OR choos$3 OR pick$3 OR determin$3) near5 pre$1equaliz$3 SAME (channel adj1 model$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 11:06 AM
L38	0	(select$3 OR choos$3 OR pick$3 OR determin$3) near4 (register OR memory OR storage) SAME (pre$1equaliz4)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 03:06 PM
L39	43	(select$3 OR choos$3 OR pick$3 OR determin$3) near4 (register OR memory OR storage) SAME (pre$1equaliz$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 03:06 PM
L40	6	(select$3 OR choos$3 OR pick$3 OR determin$3) near4 (table) SAME (pre$1equaliz$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 03:06 PM
L41	9	(select$3 OR pick$3 OR obtain$3 OR choos$3 OR determin$3 OR decid$3) near2 (set OR group OR table) near3 (coefficient$1 OR tap$1 OR weight$1) SAME pre$1equaliz$3	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 05:06 PM
L42	2	updat$3 near4 (coefficient$1 OR tap$1 OR weight$1) near4 (pre$1equaliz$3) WITH (training adj1 (mode OR phase OR period))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 05:06 PM
L43	8	updat$3 near4 (coefficient$1 OR tap$1 OR weight$1) near4 (pre$1equaliz$3) WITH (training)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/23 05:06 PM
L44	3	updat$3 near4 (coefficient$1 OR tap$1 OR weight$1) near4 (pre$1equaliz$3) WITH (initializ$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 01:06 PM

L45	119	(select$3 OR pick$3 OR obtain$3 OR choos$3) near2 (set OR group OR table OR register) near3 (pre$1distort$3) near3 (coefficient$1 OR tap$1 OR weight$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 02:06 PM
L46	0	(select$3 OR pick$3 OR obtain$3 OR choos$3) near2 (set OR group OR table OR register) near3 (pre$1distort$3) near3 (coefficient$1 OR tap$1 OR weight$1) SAME (channel adj1 model)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 02:06 PM
L47	2	(select$3 OR pick$3 OR obtain$3 OR choos$3) near2 (set OR group OR table OR register) near3 (pre$1distort$3) near3 (coefficient$1 OR tap$1 OR weight$1) AND (channel adj1 model)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 02:06 PM
L48	4115	(sav$3 OR stor$3) near4 (coefficient$1 OR tap$1 OR weight$1) near3 (different OR independent OR plurality OR several) near3 (register$1 OR table$1 OR memor$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 03:06 PM
L49	17	(sav$3 OR stor$3) near4 (equalizer OR pre$1equalizer) near2 (coefficient$1 OR tap$1 OR weight$1) near3 (different OR independent OR plurality OR several OR multiple) near3 (register$1 OR memor$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 03:06 PM
L50	51	(registers OR memories OR (memory adj1 units)) near4 (equalizer OR pre$1equalizer) near2 (coefficient$1 OR tap$1 OR weight$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	OFF	ON	2020/06/24 03:06 PM
L51	4	(registers OR memories OR (memory adj1 units)) near4 (pre$1equaliz$5) near2 (coefficient$1 OR tap$1 OR weight$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	OFF	ON	2020/06/24 03:06 PM
L52	11	(select$3 OR choos$3 OR pick$3) near3 (pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 04:06 PM
L53	2	(select$3 OR choos$3 OR pick$3) near5(initial) near4 (pre$1equaliz$3) near5 (coefficient$1 OR tap$1 OR weight$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 04:06 PM

L54	29	(select$3 OR choos$3 OR pick$3) near4 (pre$1equaliz$3) near5 (coefficient$1 OR tap$1 OR weight$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 04:06 PM
L55	23	54 AND (updat$3 OR adjust$3) near5 (coefficient$1 OR tap$1 OR weight$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 04:06 PM
L56	8	(coefficient$1 OR tap$1 OR weight$1) near6 pre$1equaliz$3 WITH (channel adj1 model)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L57	31	(coefficient$1 OR tap$1 OR weight$1) near6 pre$1equaliz$3 WITH (impulse adj1 response adj3 channel)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L58	39	(coefficient$1 OR tap$1 OR weight$1) near6 pre$1equaliz$3 WITH ((impulse adj1 response adj3 channel) OR (channel adj1 model))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L59	0	L58 AND (EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 ((channel adj1 impulse) OR (channel adj1 model))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L60	215	(coefficient$1 OR tap$1 OR weight$1) WITH (EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 ((channel adj1 impulse) OR (channel adj1 model))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L61	0	(coefficient$1 OR tap$1 OR weight$1) WITH (EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 ((channel adj1 impulse) OR (channel adj1 model)) AND (pre$1equaliz$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L62	66	(coefficient$1 OR tap$1 OR weight$1) WITH ((EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 channel) AND (pre$1equaliz$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM

L63	11	(coefficient$1 OR tap$1 OR weight$1) WITH ((EACH OR DIFFERENT OR MULTIPLE OR distinct OR plurality OR every) adj1 channel) AND ((pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L64	8	(coefficient$1 OR tap$1 OR weight$1) WITH (channel adj1 model) AND ((pre$1equaliz$3) near3 (coefficient$1 OR tap$1 OR weight$1))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L65	1	c2m AND (insertion adj1 loss) AND (package adj1 loss)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L66	2	((coefficient$1 OR tap$1 OR weight$1) near3 pre$1equaliz$3) WITH ((performance adj1 characteristic$1) OR (error adj1 signal adj1 (power OR energy)) OR (bit adj1 error adj1 rate))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L67	0	(sav$3 OR stor$3) near3 (updated OR adjusted) adj3 (coefficient$1 OR tap$1 OR weight$1) near3 pre$1equaliz$3	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L68	30	(sav$3 OR stor$3) near3 (updated OR adjusted) adj3 (coefficient$1 OR tap$1 OR weight$1) near3 equaliz$3	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L69	11	(port adj1 connector) WITH transceiver WITH pluggable	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L70	2	(port adj1 connector) WITH transceiver WITH pluggable AND pre$1equalizer$1	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L71	2	(port adj1 connector) WITH transceiver WITH pluggable AND pre$1equaliz$3	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L72	0	(chip$1to$1module OR c2m) AND (port adj1 connect$3) AND (plug$4 near3 transceiver)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM
L73	364	(port adj1 connect$3) AND (plug$4 near3 transceiver)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/24 06:06 PM

L74	13	(port adj1 connect$3) WITH (plug$4 near3 transceiver)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 06:06 AM
L75	3	(port adj1 connect$3) WITH (plug$4 near3 transceiver) AND (filter OR pre$1equaliz$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 06:06 AM
L76	13	(port adj1 connect$3) WITH (plug$4 near3 transceiver)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 06:06 AM
L77	319	(port near2 connect$3) WITH (plug$5 near3 transceiver)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 06:06 AM
L78	3	(port near2 connect$3) WITH (plug$5 near3 transceiver) WITH (port adj1 transceiver)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 06:06 AM
L79	2	(pre$1equaliz$3) near3 (coefficients OR taps OR weights OR (coefficient adj1 values) OR (tap adj1 values)) near5 (registers OR (storage adj1 units) OR memories)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	OFF	ON	2020/06/25 06:06 AM
L80	4	(pre$1equaliz$3) SAME (coefficients OR taps OR weights OR (coefficient adj1 values) OR (tap adj1 values)) near6 (registers OR (storage adj1 units) OR memories)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	OFF	ON	2020/06/25 06:06 AM
L81	1	(pre$1equaliz$3) SAME ((coefficient OR tap OR weight) near2 set) near6 (register$1 OR (storage adj1 unit$1) ormemor$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	OFF	ON	2020/06/25 06:06 AM
L82	9	(pre$1equaliz$3) SAME ((coefficient OR tap OR weight) near2 set) near6 (register$1 OR (storage adj1 unit$1) OR memor$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 06:06 AM
L83	0	(pre$1equaliz$3) SAME (sav$3 OR stor$3) near3 (each OR different OR several OR multiple) adj1 set$1 near3 (coefficient OR tap OR weight)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 06:06 AM
L84	15	(pre$1equaliz$3) SAME (each OR different OR several OR multiple) adj1 set$1 near3 (coefficient OR tap OR weight)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 06:06 AM

L85	0	(pre$1equaliz$3) SAME (port adj1 transmitter)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 10:06 AM
L86	0	(pre$1equaliz$3) SAME3 (port adj1 transmitter)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 10:06 AM
L87	0	(pre$1equaliz$3) AND (port adj1 transmitter)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 10:06 AM
L88	22	(pre$1equaliz$3) AND (port near2 transmitter)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 10:06 AM
L89	55	(pre$1equaliz$3) AND (port near2 transmit$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 10:06 AM
L90	12	(pre$1equaliz$3) AND (port near2 transceiv$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 11:06 AM
L91	14	(pre$1equaliz$3) AND (port near3 transceiv$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 11:06 AM
L92	3177	cable SAME (port near3 transceiv$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 11:06 AM
L93	1601	cable WITH (port near3 transceiv$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 11:06 AM
L94	2460	network WITH (port near1 transceiv$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 11:06 AM
L95	1497	network WITH (port adj1 transceiv$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 11:06 AM
L96	609	network near5(port adj1 transceiv$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 11:06 AM
L97	0	network near5 "port adj1 transceiv$3"	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 11:06 AM

L98	0	"port adj1 transceiv$3"	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 11:06 AM
L99	0	"port adj1 transceiver"	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 11:06 AM
L100	4775	"port transceiver"	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 11:06 AM
L101	550	"port transceiver" near5 network	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/06/25 11:06 AM
L102	483	"port transceiver" near5 network	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	OFF	ON	2020/06/25 11:06 AM
L103	1	(select$3 near4 register) WITH pre$1equaliz$3 AND (sun.inv. OR qian.inv.)	(US-PGPUB ; USPAT)	OR	ON	ON	2020/07/03 06:07 AM
L104	1	"20020141347" AND (model WITH coefficient$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/07/03 03:07 PM
L105	1	"20020141347" AND (model WITH (coefficient$1 OR tap$1 OR weight$1))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/07/03 03:07 PM
L106	160	(channel adj1 model) near4 (channel adj1 characteristic$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/07/03 03:07 PM
L107	7	(channel adj1 model) WITH (pre$1equalizer near3 (tap$1 OR coefficient$1 OR weight$1))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/07/03 04:07 PM
L108	1	"20130223506" AND (pre$1equaliz$3 WITH (fir OR filter$3))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/07/03 10:07 PM
L109	839852	20100232493and (control$4 near5 (coefficient$1 OR tap$1 OR register$1))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/07/03 11:07 PM
L110	0	"20100232493" AND (control$4 near5 (coefficient$1 OR tap$1 OR register$1))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/07/03 11:07 PM

L111	2	"20100232493" AND (control$4 WITH (coefficient$1 OR tap$1 OR register$1))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/07/03 11:07 PM
L112	2	"20100232493" AND (control$4 WITH (coefficient$1 OR tap$1 OR register$1)) AND (register WITH coefficient$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/07/03 11:07 PM
L113	1	"20130201316" AND (connector WITH port)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/07/04 08:07 AM
L114	1	"20130201316" AND (connector SAME port)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/07/04 08:07 AM
L115	2	"20130201316" AND (plug$4 SAME (modem OR transceiver))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2020/07/04 09:07 AM
L116	22	((performance adj1 characteristic$1) OR (snr OR snir OR ber) OR (signal adj2 noise adj2 ratio) OR (bit adj1 error adj1 rate) OR (error adj1 signal adj1 energy)) WITH (pre$1equaliz$3 near2 (coefficient$1 OR tap$1 OR weight$1))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/04 04:01 PM
L117	6	(ber OR (bit adj1 error adj1 rate)) WITH (pre$1equaliz$3 near2 (coefficient$1 OR tap$1 OR weight$1))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/04 05:01 PM
L118	3	(ber OR (bit adj1 error adj1 rate)) SAME ((choos$3 OR select$3 OR pick$3 OR updat$3 OR adapt$3 OR determin$3 OR calculat$3) near3 pre$1equaliz$3 near2 (coefficient$1 OR tap$1 OR weight$1))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/05 10:01 AM
L119	35	(ber OR (bit adj1 error adj1 rate)) AND ((choos$3 OR select$3 OR pick$3 OR updat$3 OR adapt$3 OR determin$3 OR calculat$3) near3 pre$1equaliz$3 near2 (coefficient$1 OR tap$1 OR weight$1))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/05 10:01 AM

L120	93	(ber OR (bit adj1 error adj1 rate)) AND (pre$1equaliz$3 near2 (coefficient$1 OR tap$1 OR weight$1))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/05 03:01 PM
L121	1	(ber OR (bit adj1 error adj1 rate)) SAME (pre$1equaliz$3 near2 (parameter$1 OR setting$1))	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/05 09:01 PM
L122	28	(ber OR (bit adj1 error adj1 rate)) WITH (pre$1equaliz$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/05 09:01 PM
L123	58	(ber OR (bit adj1 error adj1 rate)) SAME (pre$1equaliz$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (CN , FR , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/05 09:01 PM
L124	1	"20130223506" AND (different near4 channel$1 WITH pre$1equaliz$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (AU , AP , AT , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/16 04:01 PM
L125	17	((different OR each) adj1 (set$1 OR group$1)) near4(equaliz$3 OR pre$1equaliz$3) near4 (coefficients OR weights OR taps) WITH (stor$3 OR storage OR ram OR table OR memory)	(US-PGPUB ; USPAT ; USOCR ; FIT (AU , AP , AT , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/16 04:01 PM
L126	1	"20130223506" AND ((different OR distinct OR each) near7 channel$1 WITH pre$1equaliz$3)	(US-PGPUB ; USPAT ; USOCR ; FIT (AP , AT , AU , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/16 04:01 PM
L127	6535	((set$1 OR group$1)) near4(equaliz$3 OR pre$1equaliz$3 OR filter) near4 (coefficient$1 OR weight$1 OR tap$1) near8 (register OR storage OR ram OR table OR memory)	(US-PGPUB ; USPAT ; USOCR ; FIT (AP , AT , AU , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/19 10:01 AM

L132	14	((each OR every OR different) adj2 (set$1 OR group$1)) near4(equaliz$3 OR pre$1equaliz$3 OR filter$1) near4 (coefficient$1 OR weight$1 OR tap$1) near8 (separate OR different OR distinct) adj1 (register OR storage OR ram OR table OR memory) AND @ad<=20180828	(US-PGPUB ; USPAT ; USOCR ; FIT (AP , AT , AU , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/19 02:01 PM
L133	2	"20130223506" AND (channel$1 WITH (pre$1equaliz$3 OR equaliz$3))	(US-PGPUB ; USPAT ; USOCR ; FIT (AP , AT , AU , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/19 03:01 PM
L134	2	"20130223506" AND (channel$1 near5 characteristic$1)	(US-PGPUB ; USPAT ; USOCR ; FIT (AP , AT , AU , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/19 04:01 PM
L135	2	"20130223506" AND (snr)	(US-PGPUB ; USPAT ; USOCR ; FIT (AP , AT , AU , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/19 04:01 PM
L136	6	((select$3 OR choos$3 OR pick$3) near4 beam near2 pair) WITH (interfer$3 near4 (enb OR station$1 OR ue$1 OR device$1 OR unit$1))	(US-PGPUB ; USPAT ; USOCR ; FIT (AU , AP , AT , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/01/21 01:01 PM
L137	0	"20130201316" AND (port WITH equaliz$3)	(US-PGPUB ; USPAT)	OR	ON	ON	2021/01/30 05:01 PM
L138	92	((set$1 OR group$1 OR sub$1set$1 OR sub$1groups$1)) near4(equaliz$3 OR pre$1equaliz$3 OR filter) near4 (coefficient$1 OR weight$1 OR tap$1) near8 (register OR storage OR ram OR table OR memory) AND ((set$1 OR group$1 OR sub$1set$1 OR sub$1groups$1) near4 (coefficient$1 OR weight$1 OR tap$1) near6 ((different OR distict OR each) adj2 channel))	(US-PGPUB ; USPAT ; USOCR ; FIT (AP , AT , AU , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/03/22 06:03 PM

L139	0	((set$1 OR group$1 OR sub$1set$1 OR sub$1groups$1)) near4(pre$1equaliz$3) near4 (coefficient$1 OR weight$1 OR tap$1) near8 (register OR storage OR ram OR table OR memory) AND ((set$1 OR group$1 OR sub$1set$1 OR sub$1groups$1) near4 (coefficient$1 OR weight$1 OR tap$1) near6 ((different OR distict OR each) adj2 channel))	(US-PGPUB ; USPAT ; USOCR ; FIT (AP , AT , AU , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/03/23 05:03 PM
L140	0	((set$1 OR group$1 OR sub$1set$1 OR sub$1groups$1)) near4(pre$1equaliz$3) near4 (coefficients OR weights OR taps) near8 (register OR storage OR ram OR table OR memory) AND ((coefficients OR weights OR taps) near6 ((different OR distict OR each) adj2 channels))	(US-PGPUB ; USPAT ; USOCR ; FIT (AP , AT , AU , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	OFF	ON	2021/03/23 05:03 PM
L141	2	("10212260"|"20130343400"|"20140086264"|"20140146833"|"20150003505"|"20160337114"|"20200076651"|"8301036"|"9071479"|"9385859"|"9935800").PN. AND (pre$1equaliz$3)	(US-PGPUB ; USPAT)	OR	ON	ON	2021/03/23 05:03 PM
L142	1	(pre$1equaliz$3 near4 (coefficient$1 OR weight$1 OR tap$1) near8 (register OR storage OR ram OR table OR memory)) AND ((coefficient$1 OR weight$1 OR tap$1) near6 channel) AND (sun.inv. OR qian.inv.)	(US-PGPUB ; USPAT ; USOCR ; FIT (AP , AT , AU , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/03/23 09:03 PM
L143	163	(pre$1equaliz$3 near4 (coefficients OR weights OR taps)) SAME ((coefficient$1 OR weight$1 OR tap$1) near6 channel)	(US-PGPUB ; USPAT ; USOCR ; FIT (AP , AT , AU , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/03/24 10:03 AM
L144	45	(pre$1equaliz$3 near4 (coefficients OR weights OR taps) WITH (channel adj1 (model OR characteristic$1 OR estimation OR (impulse adj1 response))))	(US-PGPUB ; USPAT ; USOCR ; FIT (AP , AT , AU , CA , CH , CN , DD , DE , EA , EP , ES , FR , GB , JP , KR , OA , RU , SU , WO) ; FPRS ; EPO ; JPO ; DERWENT ; IBM_TDB)	OR	ON	ON	2021/03/24 10:03 AM

L145	1	((updat$3 OR adapt$3 OR chang$3) near3 pre$1equaliz$3 near4 coefficient$1) AND chip$1to$1module	(US-PGPUB ; USPAT)	OR	ON	ON	2021/03/25 11:03 AM
L146	0	((updat$3 OR adapt$3 OR chang$3) near3 pre$1equaliz$3 near4 coefficient$1) WITH (channel$1) AND serdes	(US-PGPUB ; USPAT)	OR	ON	ON	2021/03/25 11:03 AM
L147	1	((updat$3 OR adapt$3 OR chang$3) near3 pre$1equaliz$3 near4 coefficient$1) SAME (channel$1) AND serdes	(US-PGPUB ; USPAT)	OR	ON	ON	2021/03/25 11:03 AM
L148	3	serdes AND (chip$1to$1module) AND pre$1equaliz$3	(US-PGPUB ; USPAT)	OR	ON	ON	2021/03/25 11:03 AM
L149	3	L148 AND ((H04L25/03019 OR H04L7/0087 OR G06N20/00 OR H04B1/40 OR H04L27/01 OR H04L25/03885).cpc.)	(US-PGPUB ; USPAT)	OR	ON	ON	2021/03/25 12:03 PM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N1	3	serdes AND (chip$1to$1module) AND pre$1equaliz$3	(US-PGPUB ; USPAT)	OR	ON	ON	2021/03/25 12:03 PM

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16552927	NOA	03/31/2021	20160.0031.NPUS00

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UNITED STATES PATENT AND TRADEMARK OFFICE

PATENT APPLICATION INFORMATION RETRIEVAL SYSTEM

Doc Code: IFEE PTOL/85B-EFS

Document Description: Issue Fee Payment (PTO-85B)

Issue Fee Transmittal Form

Application Number	Filing Date	First Named Inventor	Atty. Docket No.	Confirmation No.
16552927	27-Aug-2019	Junqing SUN	20160.0031.NPUS00	1683

TITLE OF INVENTION :

SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS

Entity Status	Application Type	Art Unit	Class - Subclass	EXAMINER
Regular Undiscounted	Utility under 35 USC 111(a)	2632	219000	LEILA MALEK

Issue Fee Due	Publication Due	Total Fee(s) Due	Date Due	Prev. Paid Fee
$1200	$0	$1200	30-Jun-2021	$0

1.Change of Correspondence Address and/or Indication Of Fee Address (37 CFR 1.33 & 1.363)

Current Correspondence Address:	Current Indicated Fee Address :
63467 Ramey & Schwaller, LLP 5020 Montrose Blvd. Suite 800 Houston TX 77006 UNITED STATES 713 426 3923 tevenbly@rameyfirm.com	
☐ Change of correspondence address requested, system generated AIA/122-EFS form attached	☐ Fee Address indication requested, system generated SB/47-EFS form attached

2.Entity Status

Change in Entity Status

○ Applicant certifying micro entity status; system generated Micro Entity certification form attached. See 37 CFR 1.29.
Note: Absent a valid certification of micro entity status, issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment. If this box is checked, you will be prompted to choose a micro entity status on the gross income basis (37 CFR 1.29(a)) or the institution of higher education basis (37 CFR 1.29(d)), and make the applicable certification online.

○ 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.

Doc Code: IFEE PTOL/85B-EFS

Document Description: Issue Fee Payment (PTO-85B)

3.The Following Fee(s) Are Submitted:

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4.Firm and/or Attorney Names To Be Printed

NOTE: If no name is listed, no name will be printed
For printing on the patent front page, list to be displayed as entered

1. RAMEY & SCHWALLER LLP
2. Daniel J. Krueger
3.

5.Assignee Name(s) and Residence Data To Be Printed

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.

Name	City	State	Country	Category
CREDO TECHNOLOGY GROUP LIMITED	Grand Cayman		cayman islands	corporation

6.Signature

I certify, in accordance with 37 CFR 1.4(d)(4) that I am an attorney or agent registered to practice before the Patent and Trademark Office who has filed and has been granted power of attorney in this application. I also certify that this Fee(s) Transmittal form is being transmitted to the USPTO via EFS-WEB on the date indicated below.

Signature	/Daniel J. Krueger/	**Date**	05-06-2021
Name	Daniel Joseph Krueger	**Registration Number**	42771

WEB IFEE 1.0

Electronic Patent Application Fee Transmittal

Application Number:	16552927
Filing Date:	27-Aug-2019
Title of Invention:	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS
First Named Inventor/Applicant Name:	Junqing SUN
Filer:	Daniel Joseph Krueger/Theresa Evenbly
Attorney Docket Number:	20160.0031.NPUS00

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY APPL ISSUE FEE	1501	1	1200	1200
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1200**

Electronic Acknowledgement Receipt

EFS ID:	42653879
Application Number:	16552927
International Application Number:	
Confirmation Number:	1683
Title of Invention:	SERDES PRE-EQUALIZER HAVING ADAPTABLE PRESET COEFFICIENT REGISTERS
First Named Inventor/Applicant Name:	Junqing SUN
Customer Number:	63467
Filer:	Daniel Joseph Krueger/Theresa Evenbly
Filer Authorized By:	Daniel Joseph Krueger
Attorney Docket Number:	20160.0031.NPUS00
Receipt Date:	06-MAY-2021
Filing Date:	27-AUG-2019
Time Stamp:	13:18:02
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1200
RAM confirmation Number	E202156D17581871
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

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)	Web85b.pdf	46387 020bee63df1d5f0f2eb4fd863ad7aa9a72064fd8	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	32347 6bdf7ec0320814b1ec603bcf0e4bc304fdb51425	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	78734		

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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.

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New International Application Filed with the USPTO as a Receiving Office

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	16552927
	Filing Date	2019-08-27
	First Named Inventor	Junqing SUN
	Art Unit	2632
	Examiner Name	Malek, Leila
Change(s) applied to document, /C.G./ 4/19/2021	Attorney Docket Number	20160.0031.NPUS00

/L.M/	2	20130343400	A1	~~2014-03-27~~ 12/2013	Lusted et al.		
/L.M/	3	20140086264	A1	2014-03-27	Lusted et al.		
/L.M/	4	20140146833	A1	2014-05-29	Lusted et al.		
/L.M/	5	20150003505	A1	2015-01-01	Lusted et al.		
/L.M/	6	20160337114	A1	2016-11-17	Baden et al.		

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/L.M/	1	Information Technology - Open Systems Interconnection - Basic Reference Model: The Basic Model, 1994	

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/552,927	06/08/2021	11032111	20160.0031.NPUS00	1683

63467 7590 05/19/2021

Ramey & Schwaller, LLP
5020 Montrose Blvd.
Suite 800
Houston, TX 77006

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.

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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):

Junqing SUN, Fremont, CA;
CREDO TECHNOLOGY GROUP LIMITED, Grand Cayman, CAYMAN ISLANDS;
Haoli QIAN, Fremont, CA;

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Subject: Private PAIR Correspondence Notification for Customer Number 63467

May 20, 2021 04:07:42 AM

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5020 Montrose Blvd.
Suite 800
Houston, TX 77006
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Application	Document	Mailroom Date	Attorney Docket No.
16552927	ISSUE.NTF	05/19/2021	20160.0031.NPUS00

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