10-G BASE X &XAUI(Clause 48 &47)

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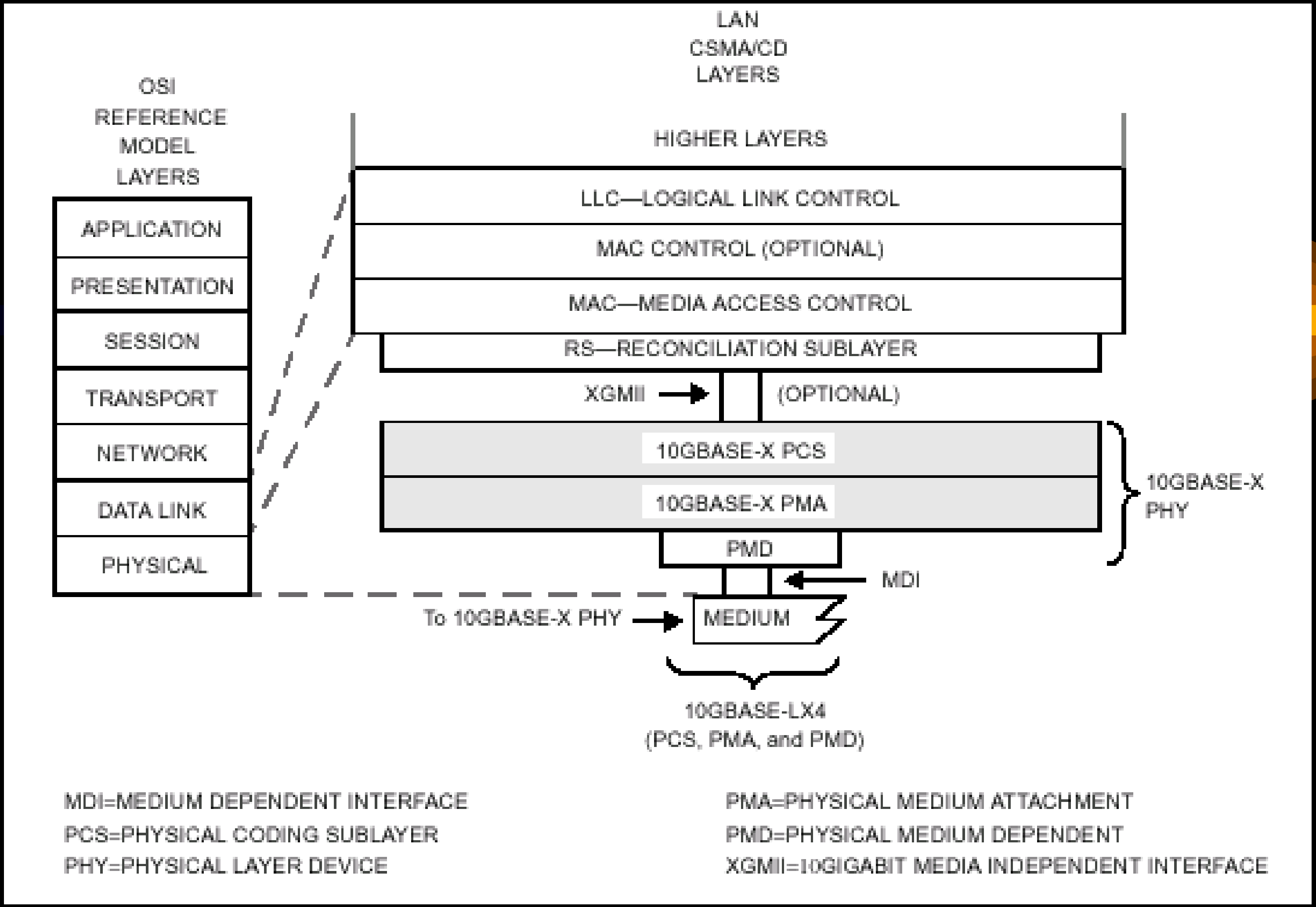
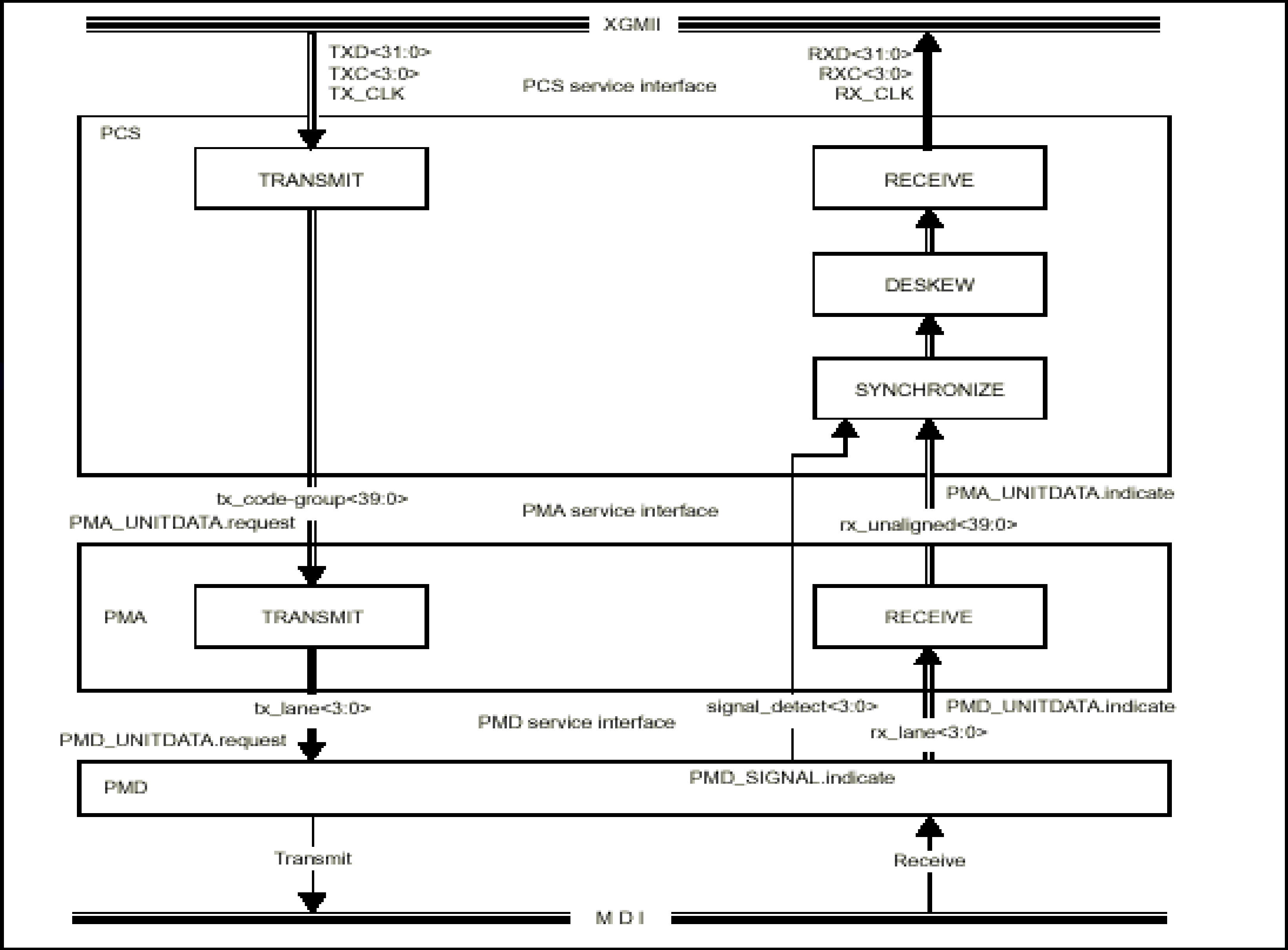
Overview

1) Clause 48
2) Clause 36 issues in Clause 48
3) Clause 47

Clause 48(8/10b PCS)



Block Diagram



Clause 48 Functionality

- Encoding of XGMII(8bits+1control bit/lane) into 10bits/lane and decode the same in the receive direction.Enables a speed of 3.125 Gbaud (+or-) 100 ppm/lane.
- Synchronization of code groups on each lane to determine code group boundaries
- Deskew of received code groups from all lanes to an alignment pattern
- Conversion of XGMII idle control characters to a randomized sequence for lane synchronization,clock rate compensation & lane-lane alignment.

Purpose of 8/10b PCS

- Why do this encoding at all :
- Enables a series of 1's or 0's to be mapped into a combination of 1's and 0's (for example 00000000 could be mapped as 1001110100 or 0110001011 depending on the running disparity which results in increased bit transition density(i.e. the transitions from 1's to 0's and vice versa).This eventually helps in easy clock recovery at the receiver side.
- Supports optional XAUI : XGMII extender which increases the physical separation between the MAC and PHY.

Clause 36 issues in Clause 48

- Running Disparity(RD)
- Comma Pattern:0011111(+veRD),1100000(-ve RD).Comma is a very unique pattern which is present in certain special code groups.This comma pattern is used for determining the 10bit-code group boundaries.
- Provides the Table of various encodings of 8 bits to 10 bits output corresponding to different values of running disparity
- Refer to Table 36-1(a)--36-2 in clause 36

Running Disparity

- Running disparity for a code-group is calculated on the basis of sub-blocks,where the six bits (abcdei) form one sub-block (six-bit sub-block)and the second four bits (fghj)form the other sub-block (four-bit subblock).Running disparity at the beginning of the six-bit sub-block is the running disparity at the end of the last code-group.Running disparity at the beginning of the four-bit sub-block is the running disparity at the end of the six-bit sublock.Running disparity at the end of the code-group is the running disparity at the end of the four-bit sub-block.

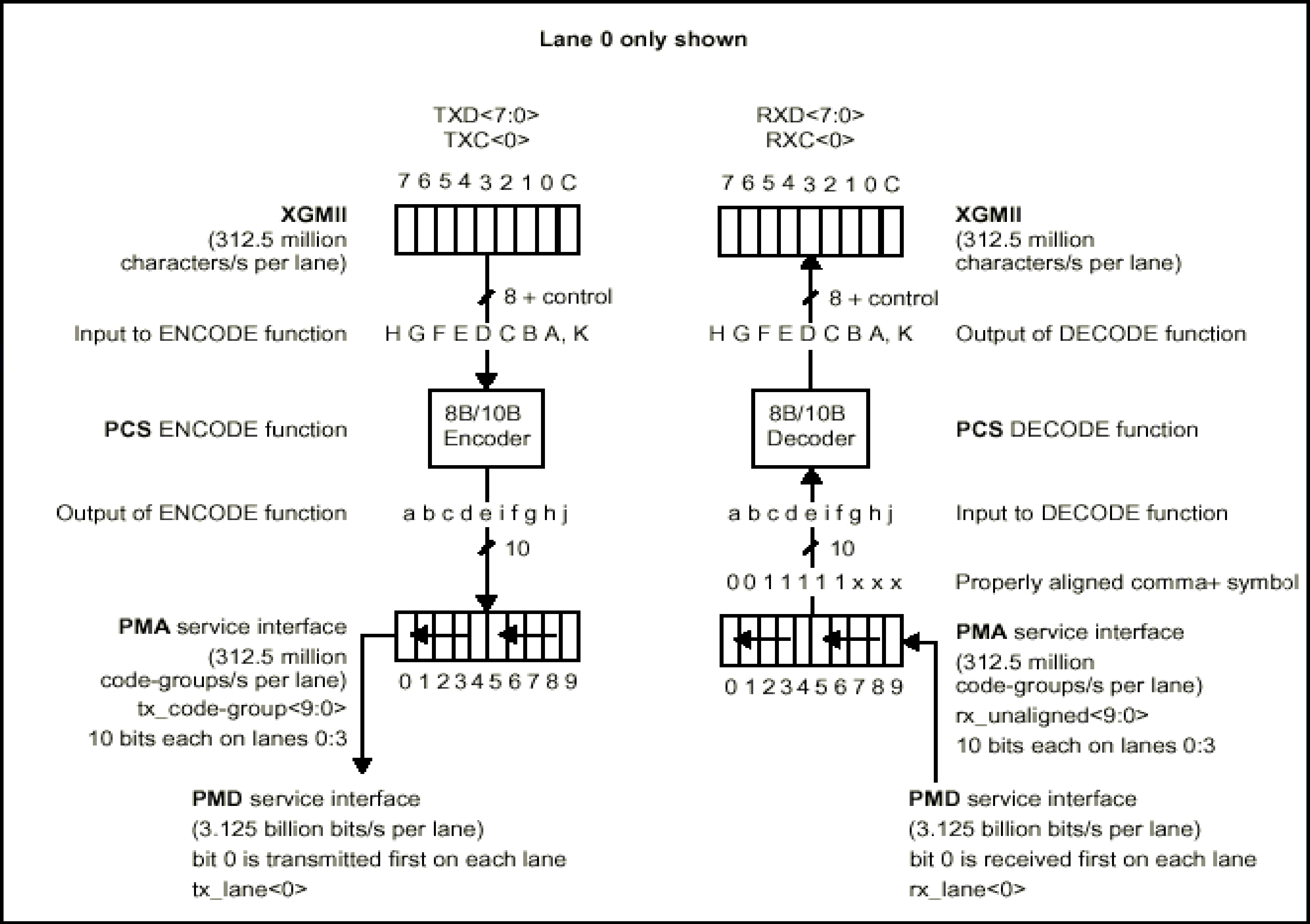
Running Disparity(contd..)

- Running disparity at the end of any sub-block is positive if the sub-block contains more ones than zeros.It is also positive at the end of the six-bit sub-block if the six-bit sub-block is 000111,and it is positive at the end of the four-bit sub-block if the four-bit sub-block is 0011;
- Running disparity at the end of any sub-block is negative if the sub-block contains more zeros than ones.It is also negative at the end of the six-bit sub-block if the six-bit sub-block is 111000,and it is negative at the end of the four-bit sub-block if the four-bit sub-block is 1100;
- Otherwise,running disparity at the end of the sub-block is the same as at the beginning of the sub-block.

8/10b Encoding/Decoding

- Encoder : 8 bits+1 control bit/lane is fed into the encoder.Encoder determines if the 10 bit output is a data or a special code group depending on the control bit.Encodes the 8 bits into 10 bit output for the given running disparity.Each time the encoder calculates a new value for the Running Disparity depending on the 10-bit output.
- Decoder : The decoder decodes the 10-bit input back into 8-bit output for the given Running Disparity.

8/10b Encoding/Decoding



Running Disparity(RD)and Encoding Example(8/10b operation)

- Assume Transmission/lane.Initial running disparity is negative for transmitter.8bit output from XGMII(TXD and TXC) into PCS.
- PCS Checks for TXC line.If TXC=1 it's a special code group(K).TXC=0 it's a Data Code group(D).so encodes the TXD(8 bit) output corresponding to -ve RD into 10 Bit output and transmits to PMA.
- Assume the 10-bit output as 1010011011.Split into 101001 and 1011
- 101001(Zeros=Ones).So RD at end of six bit subblock is same as that at the beginning which is negative here.Hence RD at end of six bit subblock is -ve which in turn is the RD at the beginning of 4-bit sub block.
- 1011(ones>zeros).Hence RD is +ve and this is the RD at end of 4-bit sub block.This in turn is used for encoding of the next 8 bit output and the above process repeated.

Running Disparity & Decoding Example(8/10b operation)

- Receiver receives 1010011011.Initial RD is either -ve or +ve.Assume its -ve,for this RD receiver finds for the unique 10-bit output and decodes into a corresponding 8-bit output and passes it to the TXD line of XGMII.TXC gets asserted if it's a K code group and deasserted if it's a D code group.If the receiver doesn't find a 10-bit output for the current RD it deems it to be a invalid code group and sends error messages to XGMII.
- As explained earlier,RD for this 10-bit output is calculated and this new RD is used as the basis for the next 10-bit output to be decoded into a corresponding 8-bit output across the XGMII and the process repeated.
- Invalid code groups initiating error messages is proportional to the BER(Bit Error Rate) .Lower the BER better is the link.

Example 2: Error Case(Error not detected at the code group where it occurred but results in an invalid code group later).

Stream		Code-group					Code-group					Code-group	
	RD		RD		RD		RD		RD		RD		RD
Transmitted code-group	–	D21.1			–	D10.2			–	D23.5			+
Transmitted bit stream	–	101010	-	1001	–	010101	–	0101	–	111010	+	1010	+
Received bit stream	–	101010	-	1011[a]	+	010101	+	0101	+	111010	+[b]	1010	+
Received code-group	–	D21.0			+	D10.2			+	invalid code-group[b]			+[c]

[a]Bit error introduced (1001 ⇒ 1011)

[b]Nonzero disparity blocks must alternate in polarity (+ ⇒ –). In this case, RD does not alternate (+ ⇒ +), the received code group is not found in the Current RD+ column in either Table 36–1a or Table 36–2, and an invalid code-group is recognized.

[c]Running disparity is calculated on the received code-group regardless of the validity of the received code-group. Nonzero disparity blocks prevent the propagation of errors and normalize running disparity to the transmitted bit stream (i.e., equivalent to the received bit stream had an error not occurred).

PCS Code Groups

- Idle of XGMII mapped to /K/ or /A/ or /R/
- /K/-Contains the Comma pattern for lane synchronization.
- /A/-Lane to lane alignment(performs deskew).
- /R/-Skip code group for clock rate compensation.Inserted or deleted depending on the XGMII idle inserted or deleted.Neutral RD,hence current RD not affected by /R/'s insertion or deletion.(associated with MAC pacing).
- /S/-Maps to XGMII start control character.
- /T/-Maps to XGMII terminate control character.
- /E/-Conveys errors(RD,Invalid code groups) to XGMII.
- /Q/-For XGMII local or remote fault.

XGMII -- PCS

XGMII

T/RXD<7:0>	I	I	S	Dp	D	D	D	---	D	D	D	D	I	I	I	I	I	I
T/RXD<15:8>	I	I	Dp	Dp	D	D	D	---	D	D	D	T	I	I	I	I	I	I
T/RXD<23:16>	I	I	Dp	Dp	D	D	D	---	D	D	D	I	I	I	I	I	I	I
T/RXD<31:24>	I	I	Dp	Ds	D	D	D	---	D	D	D	I	I	I	I	I	I	I

PCS

LANE 0	K	R	S	Dp	D	D	D	---	D	D	D	D	A	R	R	K	K	R
LANE 1	K	R	Dp	Dp	D	D	D	---	D	D	D	T	A	R	R	K	K	R
LANE 2	K	R	Dp	Dp	D	D	D	---	D	D	D	K	A	R	R	K	K	R
LANE 3	K	R	Dp	Ds	D	D	D	---	D	D	D	K	A	R	R	K	K	R

Legend:
Dp represents a data character containing the preamble pattern
Ds represents a data character containing the SFD pattern

XGMII-PCS Mapping

XGMII TXC	XGMII TXD	PCS code-group	Description
0	00 through FF	Dxx.y	Normal data transmission
1	07	K28.0 or K28.3 or K28.5	Idle in ||I||
1	07	K28.5	Idle in ||T||
1	9C	K28.4	Sequence
1	FB	K27.7	Start
1	FD	K29.7	Terminate
1	FE	K30.7	Error
1	Other value in Table 36-2	See Table 36-2	Reserved XGMII character
1	Any other value	K30.7	Invalid XGMII character
NOTE—Values in TXD column are in hexadecimal.			

PCS to XGMII Mapping

XGMII RXC	XGMII RXD	PCS code-group	Description
0	00 through FF	Dxx.y	Normal data reception
1	07	K28.0 or K28.3 or K28.5	Idle in ||I||
1	07	K28.5	Idle in ||T||
1	9C	K28.4	Sequence
1	FB	K27.7	Start
1	FD	K29.7	Terminate
1	FE	K30.7	Error
1	FE	Invalid code-group	Received code-group
1	See Table 36-2	Other valid code-group	Received reserved code-group
NOTE—Values in RXD column are in hexadecimal.			

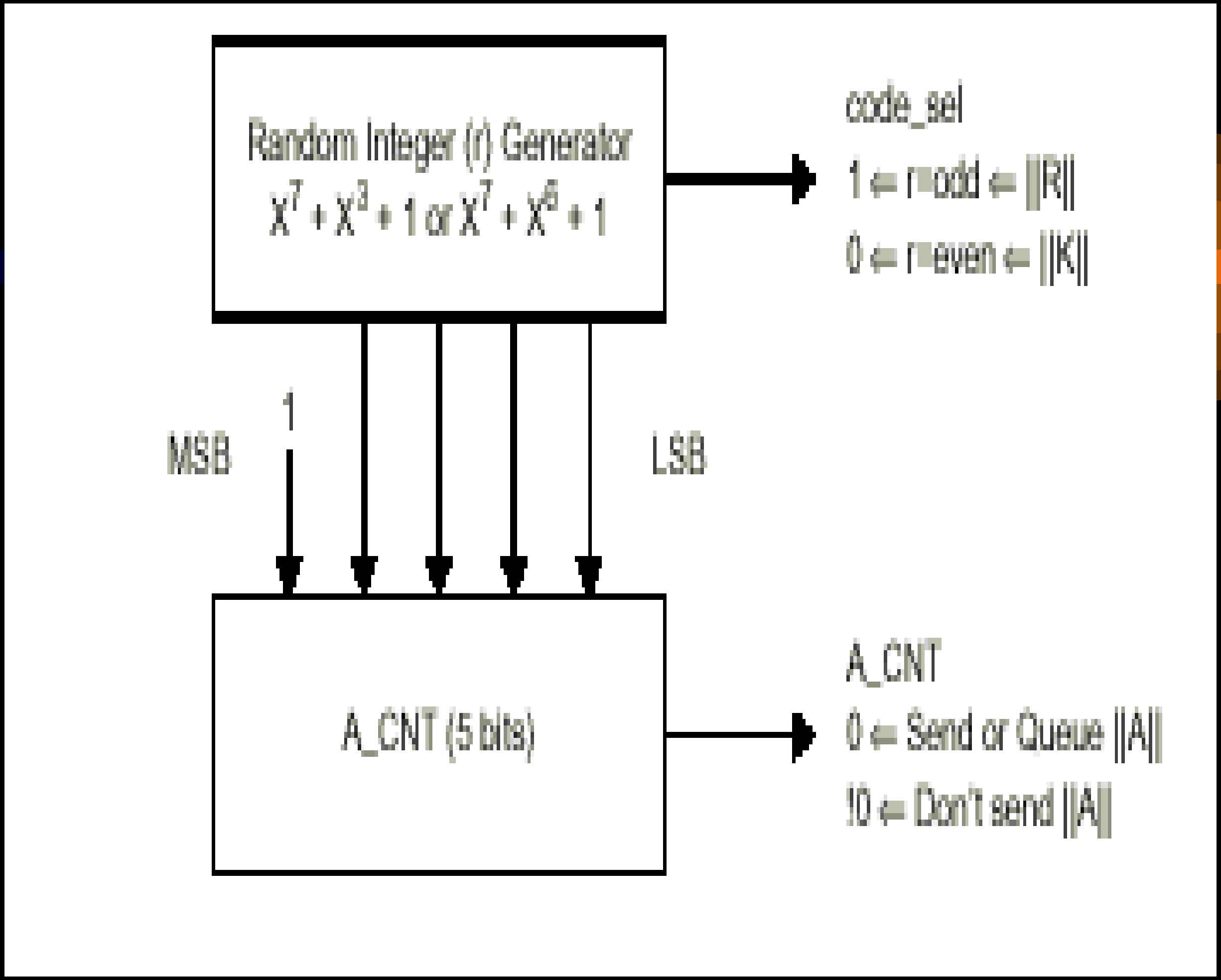
PCS Ordered Set

Code	Ordered_Set	Number of Code-Groups	Encoding
||I||	**Idle**		**Substitute for XGMII Idle**
||K||	Sync column	4	/K28.5/K28.5/K28.5/K28.5/
||R||	Skip column	4	/K28.0/K28.0/K28.0/K28.0/
||A||	Align column	4	/K28.3/K28.3/K28.3/K28.3/
	Encapsulation		
||S||	Start column	4	/K27.7/Dx.y/Dx.y/Dx.y/[1]
||T||	Terminate column	4	Terminate code-group in any lane
||T_0||	Terminate in Lane 0	4	/K29.7/K28.5/K28.5/K28.5/
||T_1||	Terminate in Lane 1	4	/Dx.y/K29.7/K28.5/K28.5/[1]
||T_2||	Terminate in Lane 2	4	/Dx.y/Dx.y/K29.7/K28.5/[1]
||T_3||	Terminate in Lane 3	4	/Dx.y/Dx.y/Dx.y/K29.7/[1]
	Control		
/E/	Error code-group	1	/K30.7/
	Link Status		
||Q||	Sequence ordered_set	4	/K28.4/Dx.y/Dx.y/Dx.y/[1]
||LF||	Local_Fault	4	/K28.4/D0.0/D0.0/D1.0/
||RF||	Remote_Fault	4	/K28.4/D0.0/D0.0/D2.0/
||Qrsvd||	Reserved	4	!||LF|| and !||RF||
	Reserved		
||Fsig||	Signal ordered_set	4	/K28.2/Dx.y/Dx.y/Dx.y/[1,2]

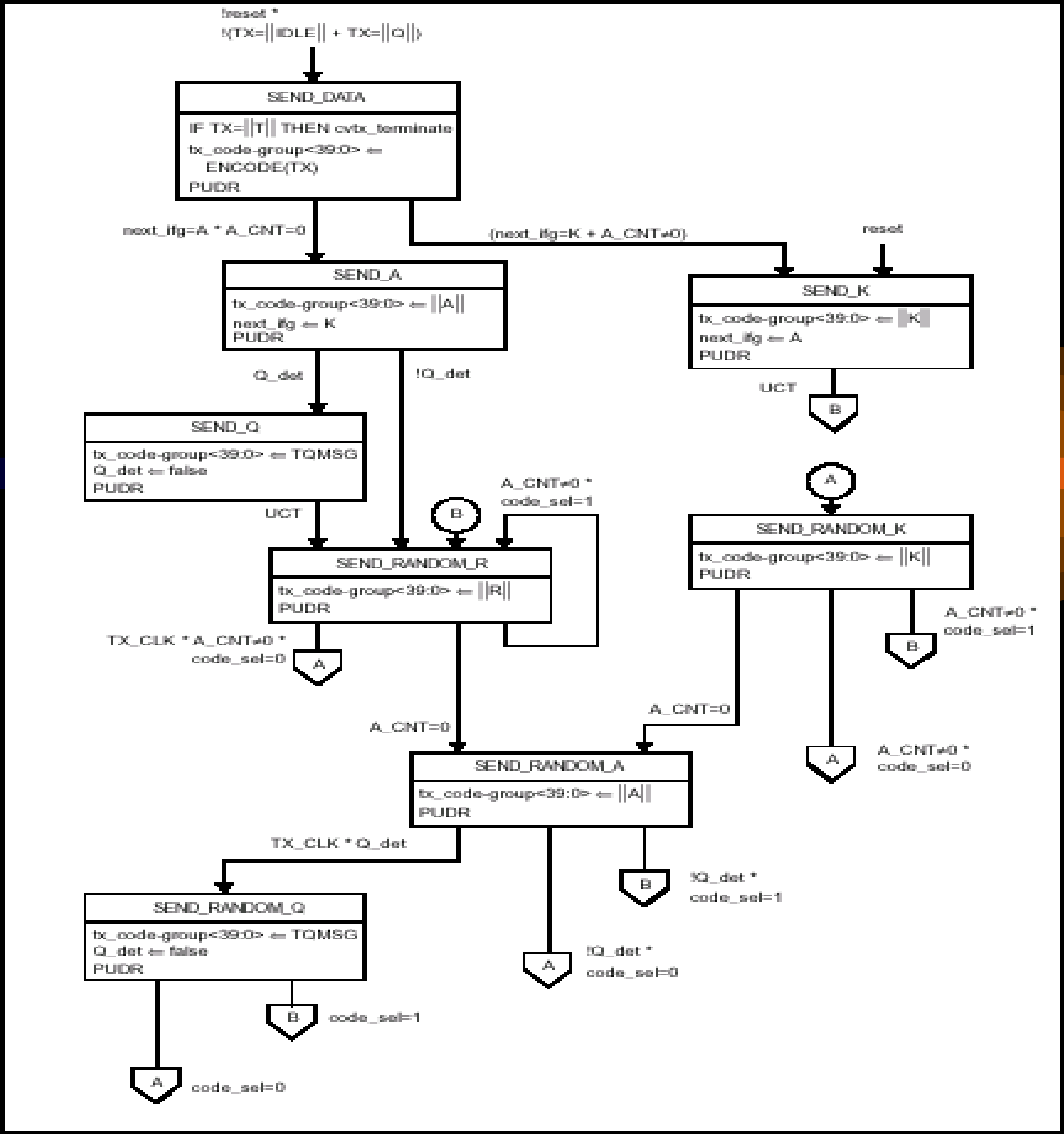
NOTE1—/Dx.y/ indicates any data code-group

NOTE2—Reserved for 10 Gigabit Fibre Channel (10GFC) use. 10 GFC is ANSI NCITS T11 project 1413-D.

PCS Idle Randomizer-- Determines if /K/,/A/ or/R/ is to be sent.Helps in reducing the Electromagnetic Interference by randomizing Idle.



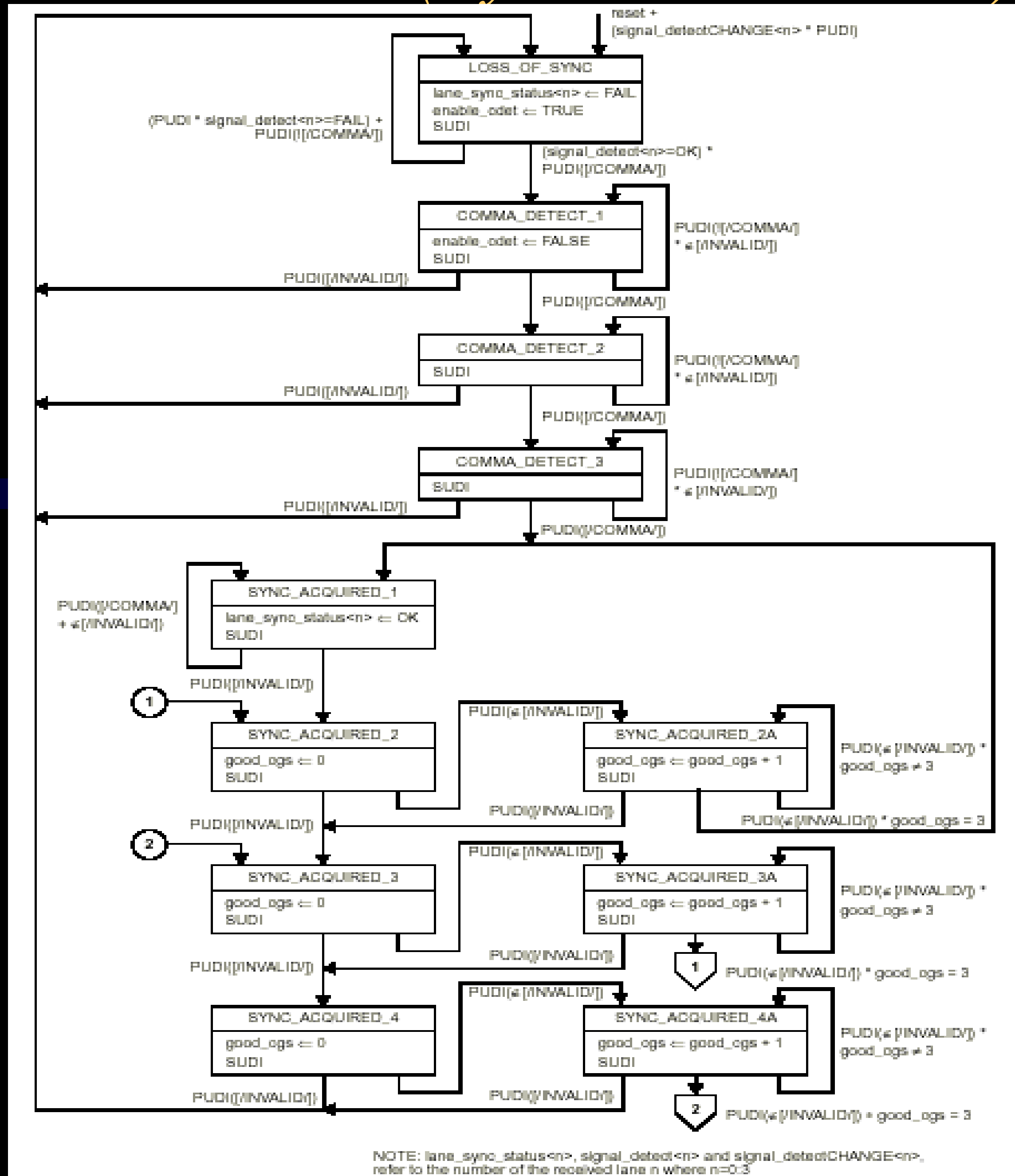
PCS Transmit State Diagram



PCS Transmit Process

- This helps in determining if /K/,/A/ or /R/ is to be sent depending on the various variables involved in the state diagram.
- This process also encodes the data stream(from start to terminate) coming from the XGMII.

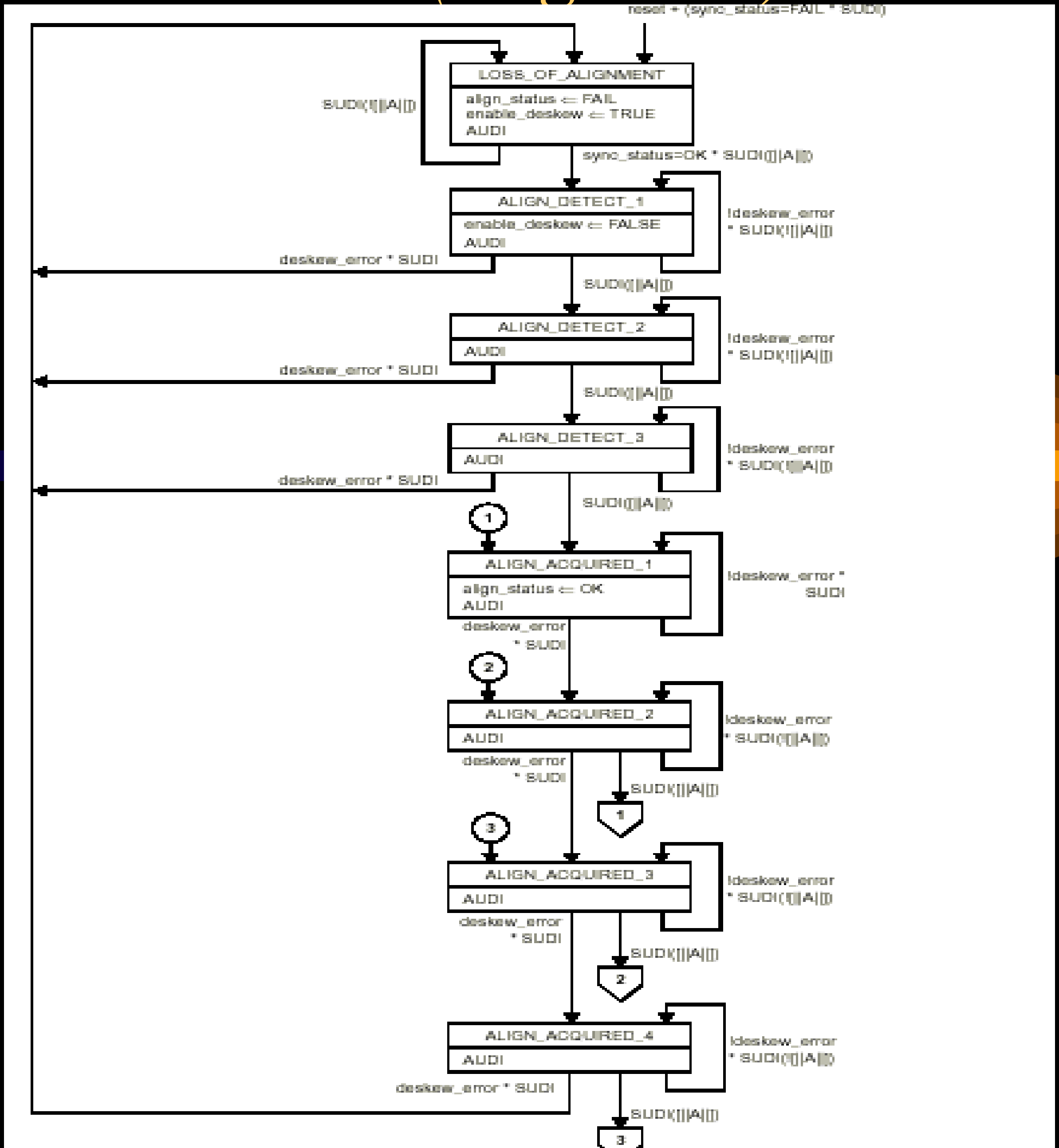
PCS Receive(Synchronization)



Why Sync Needed

- Assume initial conditions.Receiver waits for a comma pattern.If It finds 4 commas then the receiver begins its operation and if it acquires alignment goes on to receive the frame.
- Assume that the receiver receives
- 1010011111001110100100110101010111101001...The underlined bit pattern represents the comma.Hence the code group gets aligned from the beginning of the comma code group as
- 0011111001/1101001001/1010101011/1101001...
- Hence the 10-bit output to be decoded are as shown above.Hence the comma detection determines where the 10-bit stream starts and upon reception of 4 commas the receiver acquires sync.

PCS Receive(Alignment)



Why Alignment Needed

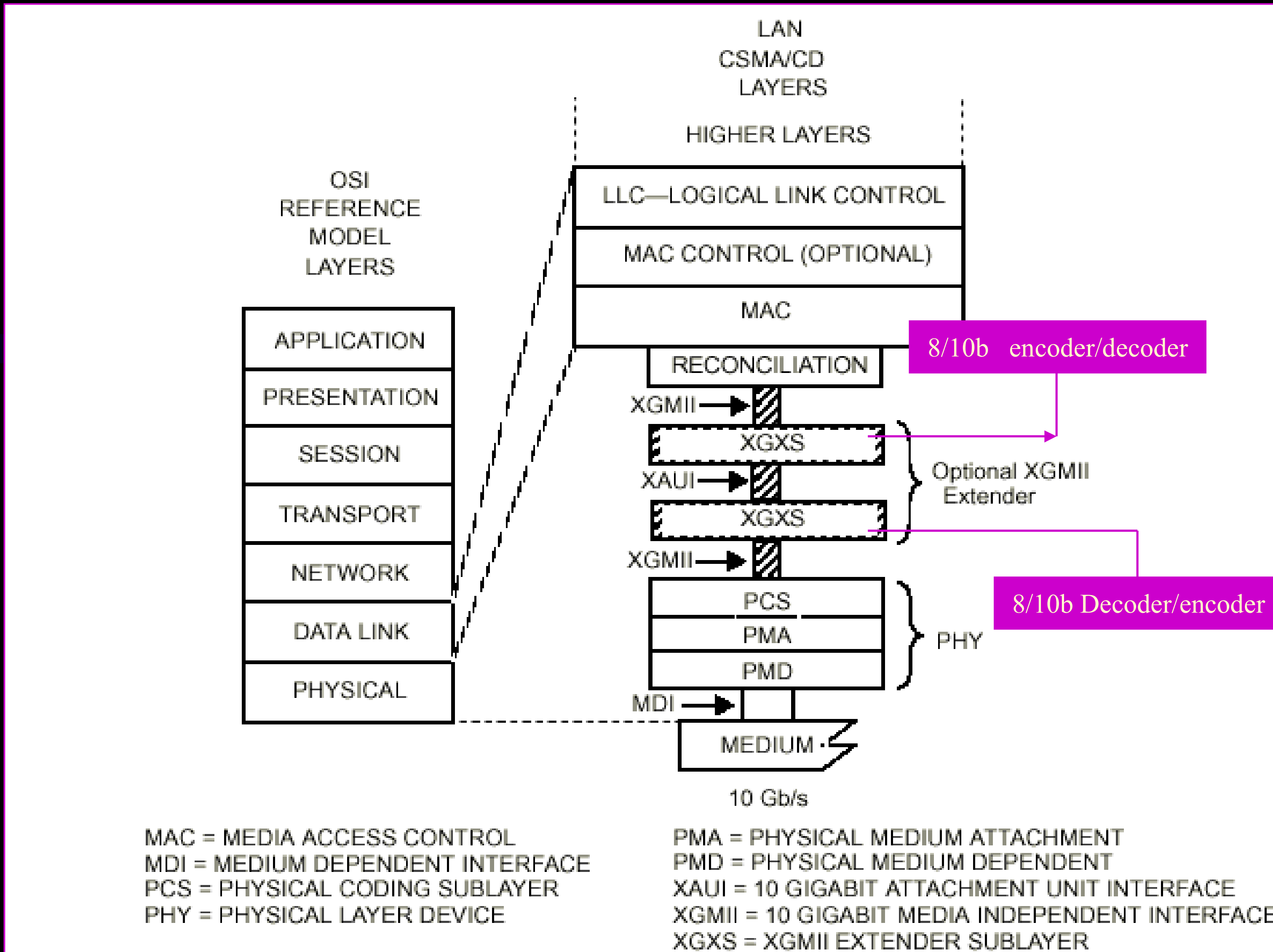
- Why need alignment :Alignment enables all the code groups in all lanes to be aligned with each other.
- Assume that the receiver has acquired sync and code sequence across lanes as shown below

Lane 0	Lane 1	Lane 2	Lane 3
K	--	--	K
A	K	K	A
--	A	A	--

- Assume case where there is no alignment as shown above
- The Enable_Deskew process as shown in the state diagram may include a scheme where it finds a A in less than 4 lanes and delays the code groups across the lanes so that the code groupings change as

- Lane 0 Lane 1 Lane 2 Lane 3
- -- -- -- --
- K K K K
- A A A A
- (ie) Lane 0 and Lane 1 gets delayed so that all the lanes align as shown above.The Enable_Deskew process is system dependent and could be implemented any way.The standard specifies that a column of A's should be separated by a random integer in the range from 16 to 31 columns.

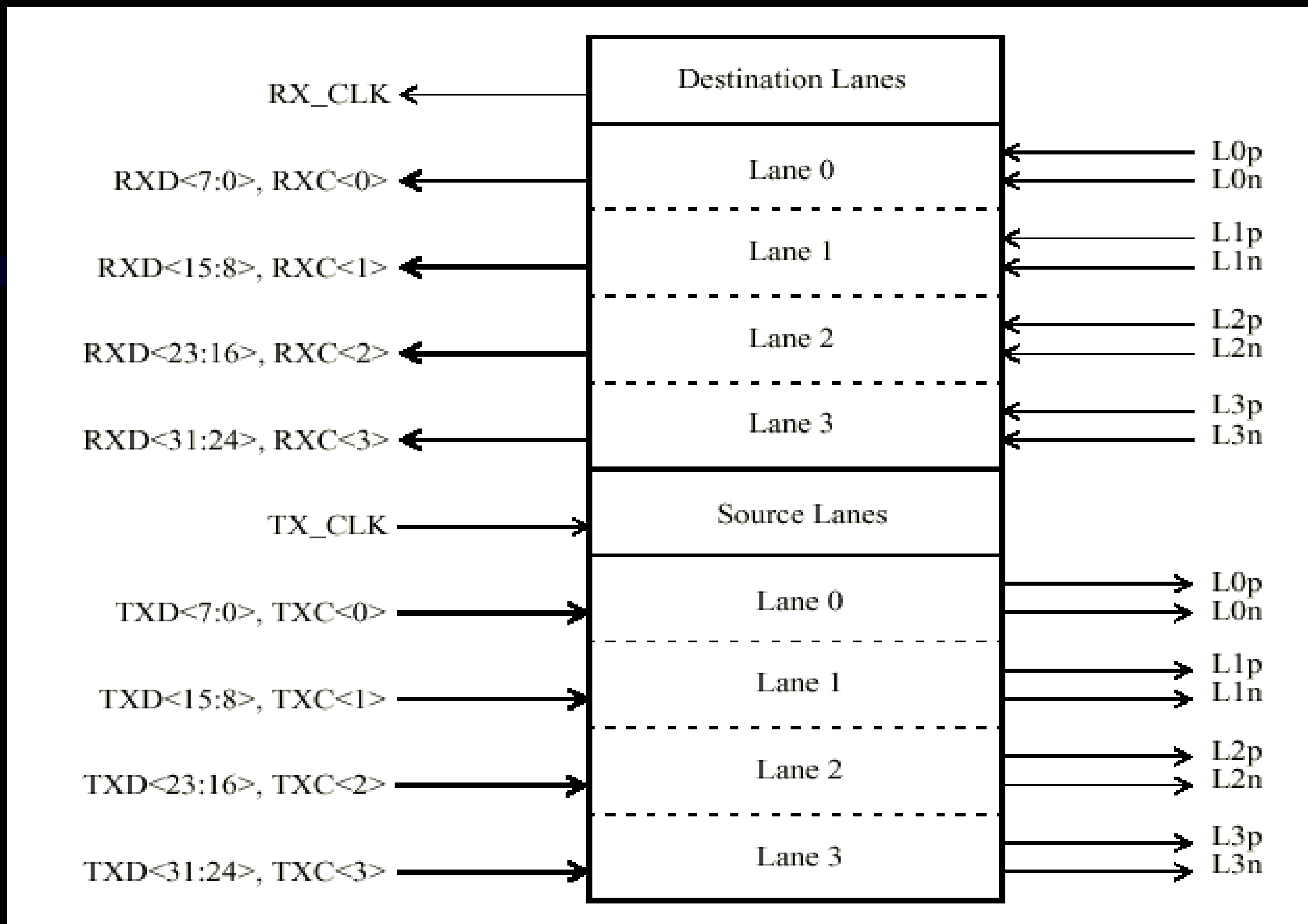
Clause 47 -- XAUI



XAUI Characteristics

- Increases the operational distance of the XGMII,increases the physical separation between the MAC and PHY.XAUI spans over a distance of 50 cm.
- Reduces the number of interface pin count.XGMII-(32+4+1)*2=74(pin counts).XAUI-(4+4)*2=16(pin counts).A reduction of (74-16)=58(pin counts) is achieved in the XAUI case.
- XGXS uses the same code and coding rules as 10GBase-X PCS(8/10b).

XGXS Inputs & Outputs



Conclusion

- 10GBase – X , XAUI – One of the different implementations in the 10Gig standard.
- All the diagrams in this presentation are taken from the IEEE 802.3ae standard.

Questions & Concerns

Thank You