149.3.9 MultiGBASE-T1 A operations, administration, and maintenance (OAM)

[Note for editor: Ignore headers/footers. Section numbering is incorrect due to starting from Clause 149, so everything in this document under "149.3.9" should replace 192.3.7. That is everything except PICS goes into 192.3.7. Cross references updated with editorial license as the current cross references to clause 149 in most cases become clause 192. Without EEE there is no use for the RS-FEC(16,14) described in clause 149 so that is removed in clause 192]

MultiGBASE-A operations, administration, and maintenance (OAM) is a subset of OAM as specified for MultiGBASE-T1

PHYs in 149.3.9 since EEE is not supported and OAM symbol to field mapping differs. OAM involves both HS_PATH and LS_PATH. The 10-bit OAM symbols are inserted one per

TDD burst into the OAM fields in the HS_PATH and LS_PATH. OAM bits after the first ten per burst are

reserved.

The MultiGBASE-T1 A PCS level operations, administration, and maintenance (OAM) provides an optional mechanism useful for monitoring link operation such as exchanging PHY link health status and message exchange. When OAM is implemented, behavior shall conform to the state diagrams in **Error! Reference source not found.**Figure 149–24 and **Error! Reference source not found.**Figure 149–25. OAM information is exchanged out of band between two PHYs using excess bandwidth available on the link. The OAM is strictly between two PHYs on the Physical Layer and their associated management entities if present. Passing OAM information to other layers is outside the scope of this standard.

OAM is operational as long as both PHYs implement this mechanism and the link is up. It continues to be operational during Low Power Idle, albeit the information is transferred at a slower rate during the refresh cycle.

The OAM frame data is carried in the OAM 10-bit field in the first 10 bits of each TDD burst as described in 149.3.2.2.14149.3.9.2.1 for the normal power data mode and 149.3.6.3 for low power mode. This 10-bit field is used to exchange OAM frames. The implementation of the OAM frame exchange function is optional. However, if EEE is implemented, then the OAM frame exchange function is implemented to exchange, at a minimum, the link partner OAM status.

For the remainder of this subclause, the term OAM is specific to the MultiGBASE-T1 A PCS level OAM.

149.3.9.1 Definitions

OAM frame: A frame consisting of 14 octets of data, 14 framing bits, 14 reserved bits and two 10-bit Reed-Solomon parityReserved symbols.

OAM symbol: A 10-bit symbol consisting of either one data octet plus a framing bit and a reserved bit, or a 10-bit Reserved Reed-Solomon parity symbol. Sixteen OAM symbols make up an OAM frame.

OAM field: A 10-bit field in each PHY frameTDD burst reserved for the OAM symbol as described in 149.3.9.2.1149.3.2.2.14 or in each refresh cycle as described in 149.3.6.3.

OAM message: A message contains a 4-bit message number plus 8 octets of message data (Message<7:0><7:0>) embedded in an OAM frame. The same OAM message can be repeated on multiple OAM frames.

OAM status: The 4 octets of status data (Message<11:8><7:0>) that is embedded in each OAM frame.

149.3.9.2 Functional specifications

149.3.9.2.1 MultiGBASE-T1 A OAM frame structure

Each OAM frame is made up of 16 OAM symbols. Each of the first 14 symbols is made up of one octet of data, one framing bit, and one reserved bit. The last 2 symbols are the ReservedReed-Solomon (16,14) parity symbols.

One OAM symbol is placed in the 10-bit OAM field in each PHY frameTDD burst during normal power operation in the data mode. One OAM symbol is placed in the 10-bit OAM field in each refresh cycle during Low Power Idle. The sixteen OAM symbols are consecutively inserted into sixteen consecutive PHY frames and/or refresh cyclesTDD bursts. Once the sixteen symbols of the current OAM frame are inserted, the sixteen symbols of the next OAM frame are inserted. This process is continuous without any break in the insertion of OAM symbols with the exception noted below.

When the PCS frame is operating in interleaved mode of 2x or 4x, tWhen operating in HS_TX mode the first bit of an OAM symbol (OAM<0X><0>) shall be inserted in the OAM bit of the first RS-FEC frame in the first superframe of each TDD burst prior to interleaving with each subsequenent bit inserted in the next 9 RS-FEC frames such that the OAM symbol is carried in the first 10 RS-FEC frames so that the full OAM frame can be packed into eight superframes in the 2x interleaved mode, and into four superframes in the 4x interleaved mode. When operating in LS_TX mode an OAM symbol (OAM<X><9:0>) shall be inserted in the first 10 OAM bits of the RS-FEC frame such that the OAM symbol is carried in the first 10 bits of the OAM field of the RS-FEC frame. In this way both HS_PATH and LS_PATH send and receive one OAM symbol per TDD burst.

When transitioning from normal operation to Low Power Idle, it is possible that part of the OAM frame is packed in RS frames and the remainder of the OAM frame is sent over the LPI refreshes.

When transitioning from Low Power Idle to normal operation, it is possible that part of the OAM frame is sent over the LPI refreshes and the remainder of the OAM frame is packed in RS frames. In some instances, it is possible that the remainder of the OAM frame cannot be aligned where the next OAM frame will have its first symbol (OAM<0>) inserted in the first RS frame of the superframe. In such cases, the partially transmitted OAM frame shall be interrupted according to the following rules:

- 1x interleaving — no interruption is required.
- 2x interleaving — insert 0 or 1 dummy OAM symbol into the superframe for alignment before continuing.
- 4x interleaving — insert 0 to 3 dummy OAM symbols into the superframe for alignment before continuing.

The receiver can anticipate when the dummy OAM symbols will be inserted based on the sequence of refresh and wake events.

The dummy OAM symbol is all 0's and its value is ignored at the receiver.

An example in Figure 149–21 shows two dummy OAM symbols inserted to realign OAM<0> to the 4x interleaved superframe boundary.

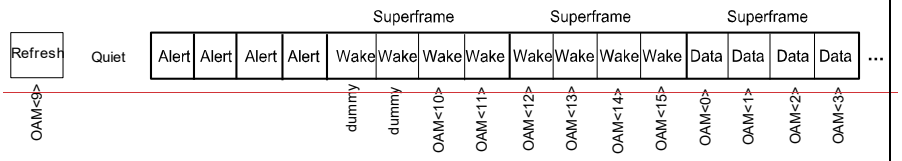

Figure 149–21—Example of 4x interleave dummy data insertion

Bit 0 of each OAM symbol is the first bit transmitted in the 10-bit OAM field. Symbol 0 is the first symbol transmitted in each OAM frame.

The OAM frame boundary can be found at the receiver by looking at bit D8. The boundary is a 0 followed by thirteen 1's followed by two don't care.

If OAM is not implemented then the 10-bit OAM field shall be set to all 0's. If the link partner does not implement OAM, the 10-bit OAM field will remain static.

149.3.9.2.2 OAM frame data

The OAM frame data is shown in **Error! Reference source not found.**Figure 149–22. OAM<*x*><*y*> refers to symbol *x*, bit *y* of the OAM frame. Reserved fields shall be set to 0.

	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Symbol 0	Reserved	0	Reserved	Reserved	Reserved	Reserved	PingRx	PingTx	SNR<1>	SNR<0>
Symbol 1	Reserved	1	Valid	Toggle	Ack	TogAck	Message_Number<3:0>			
Symbol 2	Reserved	1	Message<0><7:0>							
Symbol 3	Reserved	1	Message<1><7:0>							
Symbol 4	Reserved	1	Message<2><7:0>							
Symbol 5	Reserved	1	Message<3><7:0>							
Symbol 6	Reserved	1	Message<4><7:0>							
Symbol 7	Reserved	1	Message<5><7:0>							
Symbol 8	Reserved	1	Message<6><7:0>							
Symbol 9	Reserved	1	Message<7><7:0>							
Symbol 10	Reserved	1	Message<8><7:0>							
Symbol 11	Reserved	1	Message<9><7:0>							
Symbol 12	Reserved	1	Message<10><7:0>							
Symbol 13	Reserved	1	Message<11><7:0>							
Symbol 14	RS(16,14) parity									
Symbol 15	RS(16,14) parity									

Figure 149–22—OAM frame

Commented [SM1]: Symbol 14 and Symbol 15 are both Reserved

[EDIT NOTES: Change Symbol 14 to Reserved, Change Symbol 15 to Reserved]

149.3.9.2.3 Ping RX

The Ping RX is indicated in OAM<0><3>.

This bit is set by the PHY to the same value as the Ping TX bit received from the link partner.

149.3.9.2.4 Ping TX

The Ping TX is indicated in OAM<0><2>.

This bit is set by the PHY for the link partner to echo on Ping RX.

149.3.9.2.5 PHY health

The PHY Health (SNR<1:0>) is indicated in OAM<0><1:0>.

This status is set by the PHY to indicate the status of the receiver. The definitions of good, marginal, ~~when to request idles,~~ and when to request retrain are implementation dependent.

— 00: PHY link is failing and will drop link and relink within 2 ms to 4 ms after the end of the current OAM frame

— 01: ~~LPI refresh is insufficient to maintain PHY SNR. Request link partner to exit LPI and send idles (used only when EEE is enabled).~~RESERVED

— 10: PHY SNR is marginal

— 11: PHY SNR is good

149.3.9.2.6 OAM message valid

The OAM message valid (Valid) is indicated in OAM<1><7>.

— 0: Current OAM frame does not contain a valid OAM message

— 1: Current OAM frame contains a valid OAM message

149.3.9.2.7 OAM message toggle

The OAM message toggle (Toggle) is indicated in OAM<1><6>.

The toggle bit lets the management entity determine which OAM message is being referenced. The toggle bit in the current OAM message is set to the opposite value of the toggle bit in the previous OAM message only if link partner acknowledges the OAM message is received. This allows one OAM message to be delineated from a second OAM message since the same OAM message may be repeated over multiple OAM frames. This bit is valid only if Valid is set to 1.

149.3.9.2.8 OAM message acknowledge

The OAM message acknowledge (Ack) is indicated in OAM<1><5>.

Ack is set by the PHY to let the link partner know that the OAM message sent by the link partner was successfully received as defined in MultiGBASE-T1 OAM frame acceptance criteria~~149.3.9.2.14~~ and the PHY is ready to accept a new OAM message. An OAM message is defined to be Message_Number<3:0> and Message<7:0><7:0>.

— 0: No acknowledge

— 1: Acknowledge

149.3.9.2.9 OAM message toggle acknowledge

The OAM message toggle acknowledge (TogAck) is indicated in OAM<1><4>.

TogAck is set by the PHY to let the link partner know that the OAM message is being acknowledged. TogAck takes the value of Toggle bit of the OAM message being acknowledged. This bit is valid only if Ack is set to 1.

149.3.9.2.10 OAM message number

The OAM message number is indicated in OAM<1><3:0>.

This field is user-defined but it is recommended that it be used to indicate the meaning of the 8-octet message that follows. If used this way, up to 16 different 8-octet messages can be exchanged.

The message number is user-defined and its definition is outside the scope of this standard.

149.3.9.2.11 OAM message data

The OAM message data is indicated in OAM<9:2><7:0>.

The 8-octet message data is user-defined and its definition is outside the scope of this standard.

Ack is set by the PHY to let the link partner know that the OAM frame sent by the link partner is successfully received as defined. The OAM frame octet is the lower 8 bits of the 10-bit OAM symbol.

149.3.9.2.12 OAM status

The OAM status data is indicated in OAM<13:10><7:0>.

These 32 bits are set by the PHY to convey its status in the mr_tx_message[95:64] to the link partner.

For additional information on the usage of these bits see Annex 149B.

149.3.9.2.13 OAM Reed-Solomon

The RS(16, 14) parity symbols are indicated in OAM<15:14><9:0>.

The OAM frame shall encode the 14 data symbols using Reed-Solomon code (16,14). The FEC code used is a shortened Reed-Solomon (16,14) code over the Galois Field of $GF(2^{10})$ — a code operating on 10-bit symbols. The code encodes 14 information symbols and adds 2 parity symbols, enabling correction of up to 1 symbol error. The code is systematic, meaning that the information symbols are not disturbed in any way in the encoder and the parity symbols are added separately to each block, and is based on the generating polynomial shown in Equation (149–8).

$$G(Z) = (Z - \alpha)(Z - 1) = A_2Z^2 + A_1Z^1 + A_0Z^0 \quad (149\text{–}8)$$

where

α — is a root of the binary primitive polynomial $x^{10} + x^3 + 1$ and is represented as 0x002.
A — is a series representing the resulting polynomial coefficients of $G(Z)$, (A_2 is equal to 0x001).
Z — corresponds to a 10-bit $GF(2^{10})$ symbol.

The parity calculation shall produce the same result as the shift register implementation shown in Figure 149–23. Before calculation begins, the shift register shall be initialized to zero. The contents of the shift register are transmitted without inversion.

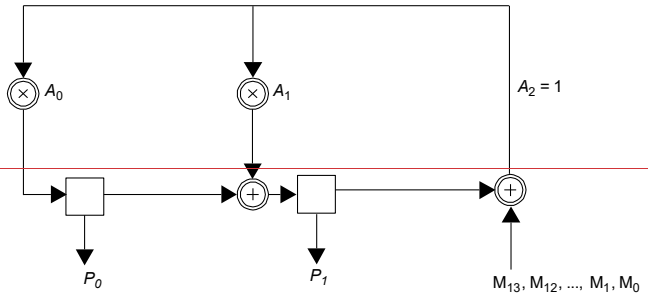

Figure 149–23—OAM FEC parity vector model

An FEC parity vector is represented by Equation (149–9).

$$P(Z) = M(Z) \bmod G(Z) \quad (149\text{–}9)$$

where

$M(Z)$ is the data vector $M(Z) = M_{13}Z^{15} + M_{12}Z^{14} + \ldots + M_0Z^2$. M_{13} is the first 10-bit data symbol and M_0 is the last. (M_{13} corresponds to OAM<0><9:0>, M_{12} corresponds to OAM<1><9:0>, etc.)

$P(Z)$ is the parity vector $P(Z) = P_1Z^1 + P_0Z^0$. P_1 (OAM<14><9:0>) is the first 10-bit parity symbol and P_0 (OAM<15><9:0>) is the last.

A data/parity symbol (d_9, d_8, …, d_0) is identified with the element: $d_9\alpha^9 + d_8\alpha^8 + \ldots + d_0\alpha^0$ in GF(2^{10}), the finite field with 2^{10} elements.

d_0 is identified as the LSB (OAM<*><0>).

d_9 is identified as the MSB (OAM<*><9>) for all symbols.

The OAM Reed-Solomon parity symbol generation/correction is required only when EEE is implemented. When all 16 symbols of the OAM are embedded in tx_RSmessage<9:0> as described in 149.3.2.2.17 then OAM<15:14><9:0> are dummy symbols and are ignored at the receiver.

149.3.9.2.14 MultiGBASE-T1 OAM frame acceptance criteria

All fields of the OAM frame shall be accepted and updated, unless any of the following occurs:

a) RS(16, 14) contains an uncorrectable error, or

b) there is an uncorrectable PHY frameRS-FEC frame on any of the 16 symbols.

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149.3.9.2.15 PHY health indicator

The PHY current health is sent to the link partner on a per OAM frame basis using the SNR<1:0> bits as described in PHY health149.3.9.2.5. It lets the link partner have an early indication of potential problems that can cause the PHY to drop link or have high error rates.

If EEE is implemented, there can be a case where a PHY's receiver can no longer maintain good SNR based on quiet/refresh cycles. Instead of dropping the link, the PHY can attempt to recover the link by forcing the link partner to exit LPI in its egress direction so that the PHY can use normal power mode to recover. This is done by transmitting SNR<1:0> with a value of 01.

If a PHY receives SNR<1:0> set to 01 by its link partner, then it cannot enter into LPI in the egress direction. If the PHY is already in LPI then the PHY shall immediately exit LPI.

149.3.9.2.16 Ping

The PingTx bit is set based on the value in mr_tx_ping. The PingRx bit is set based on the latest PingTx received from the link partner. The value in mr_rx_ping is set based on the received PingRx from the link partner. The user can determine that the link partner OAM is operating properly by toggling mr_tx_ping and observing mr_rx_ping matches after a short delay.

The Ping bits are updated on a per OAM frame basis.

149.3.9.2.17 OAM message exchange

Unlike the PHY health indicator, the ping function, and the OAM status that operate on a per OAM frame basis, the OAM message exchange operates on a per OAM message basis that may occur over many OAM frames. The OAM message exchange mechanism allows a management entity attached to a PHY and its peer attached to the link partner to asynchronously pass OAM messages and verify their delivery.

The OAM message is first written into the OAM transmit registers in the PHY. The OAM message is then read out of the OAM transmit registers and transmitted to the link partner. After the link partner receives the OAM message, it transfers it into the link partner's OAM receive registers and also sends an acknowledge back to the PHY indicating that the next OAM message can be transmitted. One OAM message can be loaded into the OAM transmit registers while another OAM message is being transmitted by the PHY to the link partner, while yet another OAM message is being read out at the link partner's OAM receive registers. The exchange of OAM messages is occurring concurrently and bi-directionally. The transfers between the management entities can be done asynchronously. On the transmit side, mr_tx_valid = 0 indicates that the next OAM message can be written into the OAM transmit registers. Once the registers are written, the management entity sets mr_tx_valid to 1 to indicate that the OAM transmit registers contain a valid OAM message. Once the message is read out atomically, the state diagram clears the mr_tx_valid to 0 to indicate that the registers are ready to accept the next OAM message.

On the receive side, mr_rx_lp_valid indicates that valid OAM message can be read from the OAM receive registers. Once these registers are read, the mr_rx_lp_valid should be cleared to 0 to indicate that the registers are ready to receive the next OAM message. If mr_rx_lp_valid is not cleared, then the OAM message transfer will eventually stall since the sender cannot send new OAM messages if the receiver does not acknowledge that an OAM message has been transferred into the OAM receive registers.

The management entities can asynchronously read mr_tx_valid and mr_rx_lp_valid to know when OAM messages can be transferred in and out of the OAM registers.

The toggle bit alternates between 0 and 1, which lets the management entity determine which OAM message is being referred to. The toggle bit transitioning rules between one OAM frame and the next OAM frame are shown in Toggle bit transition rules ~~Table 149–8~~.

Table 149–8—Toggle bit transition rules

Previous Valid	Previous Toggle	Current Valid	Current Toggle	Description
0	0	0	0	No valid OAM message
0	0	0	1	Illegal transition (Error)
0	0	1	0	New OAM message starting
0	0	1	1	Illegal transition (Error)
0	1	0	0	Illegal transition (Error)
0	1	0	1	No valid OAM message
0	1	1	0	Illegal transition (Error)
0	1	1	1	New OAM message starting
1	0	0	0	Illegal transition (Error)
1	0	0	1	Received acknowledge, no new OAM message to send
1	0	1	0	Repeating current OAM message, waiting for link partner's acknowledge
1	0	1	1	Previous OAM message ending, new OAM message starting
1	1	0	0	Received acknowledge, no new OAM message to send
1	1	0	1	Illegal transition (Error)
1	1	1	0	Previous OAM message ending, new OAM message starting
1	1	1	1	Repeating current OAM message, waiting for link partner's acknowledge

149.3.9.3 State diagram variable to OAM register mapping

The state diagrams of **Error! Reference source not found.**~~Figure 149–24~~ and **Error! Reference source not found.**~~Figure 149–25~~ generate and accept variables of the form "mr_x," where x is an individual signal name. These variables comprise a management interface to communicate the OAM information to and from the management entity. Clause 45 MDIO registers are defined in MMD3 to support the OAM. The Clause 45 MDIO electrical interface is optional. Where no physical embodiment of the MDIO exists,

provision of an equivalent mechanism to access the information is recommended. Table 97–6 and State variables to OAM register mapping ~~Table 149–9~~ describe the MDIO register to the state diagrams variable mapping.

Table 149–9—State variables to OAM register mapping

MDIO control/status variable	PCS register name	Register/bit number	PCS control/status variable
MultiGBASE-T1 OAM status Message 8	MultiGBASE-T1 OAM status message register	3.2318.7:0	mr_tx_message[71:64]
MultiGBASE-T1 OAM status Message 9	MultiGBASE-T1 OAM status message register	3.2318.15:8	mr_tx_message[79:72]
MultiGBASE-T1 OAM status Message 10	MultiGBASE-T1 OAM status message register	3.2319.7:0	mr_tx_message[87:80]
MultiGBASE-T1 OAM status Message 11	MultiGBASE-T1 OAM status message register	3.2319.15:8	mr_tx_message[95:88]
Link partner MultiGBASE-T1 OAM status Message 8	Link partner MultiGBASE-T1 OAM status message register	3.2320.7:0	mr_rx_lp_message[71:64]
Link partner MultiGBASE-T1 OAM status Message 9	Link partner MultiGBASE-T1 OAM status message register	3.2320.15:8	mr_rx_lp_message[79:72]
Link partner MultiGBASE-T1 OAM status Message 10	Link partner MultiGBASE-T1 OAM status message register	3.2321.7:0	mr_rx_lp_message[87:80]
Link partner MultiGBASE-T1 OAM status Message 11	Link partner MultiGBASE-T1 OAM status message register	3.2321.15:8	mr_rx_lp_message[95:88]

[Note for Editor: Above registers are defined for MultGBASE-T1 but can be reused with same definition for MultiGBASE-A, is that sufficient or do register names need to be updated?]

149.3.9.4 Detailed functions and state diagrams

149.3.9.4.1 State diagram conventions

The body of this subclause is composed of state diagrams, including the associated definitions of variables, counters, and functions. Should there be a discrepancy between a state diagram and descriptive text, the state diagram prevails.

149.3.9.4.2 State diagram parameters

149.3.9.4.3 Variables

frame_boundary
Frame boundary detection based on the latest 16 rx_oam_field<8> received. The leftmost bit is the earliest received bit.
Values:
TRUE: latest 16 rx_oam_field<8> = 01111111111111xx
FALSE: latest 16 rx_oam_field<8> ≠ 01111111111111xx

link_status
The link_status parameter set by PMA Link Monitor and passed to the PCS via the PMA_LINK.indication primitive. This variable takes the values of OK or FAIL.

mr_rx_lp_message[95:0]
Twelve octet OAM message from the link partner. mr_rx_lp_message[63:0] in this variable is valid only when mr_rx_lp_valid is 1. mr_rx_lp_message[95:64] is always valid and continuously updated.

mr_rx_lp_message_num[3:0]
Four bit message number from the link partner. The value in this variable is valid only when mr_rx_lp_valid is 1.

mr_rx_lp_SNR[1:0]
Link partner health status.
Values:
00: PHY link is failing and will drop link and relink within 2 ms to 4 ms after the end of the current OAM frame.
01: ~~LPI refresh is insufficient to maintain PHY SNR. Request link partner to exit LPI~~RESERVED ~~and send idles (used only when EEE is enabled).~~
10: PHY SNR is marginal.
11: PHY SNR is good.
The threshold for the status is implementation dependent.

mr_rx_lp_toggle
The toggle bit value associated with the eight octet BASE-T1 OAM message from the link partner.
Values:
The toggle bit alternates between 0 and 1.

mr_rx_lp_valid
: Indicates whether the OAM message in mr_rx_lp_message[63:0], mr_rx_lp_message_num[3:0] and the toggle bit in mr_rx_lp_toggle is valid or not. This variable should be cleared when mr_rx_lp_message[63:48] is read and is not explicitly shown in the state diagram. The clearing of this variable indicates to the state diagram that the BASE-T1 OAM message is read by the user and the state diagram can proceed to load in the next BASE-T1 OAM message.
Values:
0: invalid
1: valid

mr_rx_ping
: Echoed ping value from the link partner.
Values:
The value can be 0 or 1.

mr_tx_message[95:0]
: Eight-octet BASE-T1 OAM message and four-octet MultiGBASE-T1 status transmitted by the local PHY. mr_tx_message[63:0] in this variable is valid only when mr_tx_valid is 1. mr_tx_message[95:64] in this variable is always valid.

mr_tx_message_num[3:0]
: Four-bit message number transmitted by the local PHY. The value in this variable is valid only when mr_tx_valid is 1.

mr_tx_ping
: Ping value transmitted by the local PHY.
Values:
The value can be 0 or 1.

mr_tx_received
: Indicates whether the most recently transmitted BASE-T1 OAM message with a toggle bit value of mr_tx_received_toggle was received, read, and acknowledged by the link partner. This variable shall clear on read.
Values:
0: BASE-T1 OAM message was not received and read by the link partner.
1: BASE-T1 OAM message was received by the link partner.

mr_tx_received_toggle
: Toggle bit value of the BASE-T1 OAM message that was received, read, and most recently acknowledged by the link partner. This bit is valid only if mr_tx_received is 1.
Values:
The value can be 0 or 1.

mr_tx_SNR[1:0]

Status register indicating PHY health status.

Values:

00: PHY link is failing and will drop link and relink within 2 to 4 ms after the end of the current OAM frame.

01: LPI refresh is insufficient to maintain PHY SNR. Request link partner to exit LPI and send idles (used only when EEE is enabled).RESERVED

10: PHY SNR is marginal.

11: PHY SNR is good.

The threshold for the status is implementation dependent.

mr_tx_toggle

The toggle bit value associated with the eight-octet BASE-T1 OAM message transmitted by the PHY. The value is automatically set by the state diagram and cannot be set by the user. This bit should be read and recorded prior to setting mr_tx_valid to 1.

Values:

The toggle bit alternates between 0 and 1.

mr_tx_valid

Indicates whether BASE-T1 OAM message in mr_tx_message[63:0] and mr_rx_lp_message_num[3:0] is valid or not. This register will be cleared by the state diagram to indicate whether the next BASE-T1 OAM message can be written into the registers.

Values:

0: invalid

1: valid

reset

Reset

Values:

FALSE: OAM circuit is not in reset.

TRUE: OAM circuit is in reset.

rs_check

Status of the latest rs_correct() operation

Values:

GOOD: no errors or correctable error

BAD: uncorrectable error

rx_ack

Acknowledge from link partner in response to PHY's BASE-T1 OAM message.

Values:

0: no acknowledge

1: acknowledge

rx_ack_toggle

The toggle value corresponding to the PHY's BASE-T1 OAM message that the link partner is acknowledging. This value is valid only if the rx_ack is set to 1.

Values:

The toggle bit can take on values of 0 or 1.

rx_boundary

This variable is set to TRUE whenever the receive data stream reaches the end of a Reed-Solomon frame and a dummya complete 10-bit OAM symbol is not expected available pdr

MultiGBASE-A OAM frame structure149.3.9.2.1 during normal power operation in the data mode, or at the end of a received refresh cycle during Low Power Idle operation. This variable is set to FALSE at other times.
Values:
FALSE: Receive stream is not at a boundary end.
TRUE: Receive stream is at a boundary end.

rx_exp_toggle
This variable holds the expected toggle value of the next BASE-T1 OAM message. This is normally the opposite value of the current toggle value, but shall reset on error conditions where two back-to-back BASE-T1 OAM messages separated by BASE-T1 OAM frames without a valid message have the same toggle value.
Values:
The toggle bit can take on values of 0 or 1.

rx_lp_ack
Acknowledge from PHY in response to link partner's BASE-T1 OAM message. Indicates whether valid BASE-T1 OAM message from the link partner has been sampled into the PHY's registers.
Values:
0: no acknowledge / not sampled
1: acknowledge / sampled

rx_lp_ping
Ping value received from the link partner that is looped back.
Values:
The value can be 0 or 1.

rx_lp_toggle
The toggle bit value in the previous BASE-T1 OAM frame received from the link partner.
Values:
The toggle bit alternates between 0 and 1.

rx_lp_valid
Indicates whether BASE-T1 OAM message in previous BASE-T1 OAM frame received from the link partner is valid or not.
Values:
0: invalid
1: valid

rx_oam_field<9:0>
Ten-bit BASE-T1 OAM symbol extracted from a received Reed-Solomon frame during normal power operationTDD burst in during the data mode, or from a received refresh cycle during Low Power Idle operation.

rx_oam<15 to 0><9:0>
Raw 16-symbol OAM frame received from the link partner.

SNR[1:0]
PHY health status.
Values:
00: PHY link is failing and will drop link and relink within 2 ms to 4 ms after the end of the current OAM frame.
01: LPI refresh is insufficient to maintain PHY SNR. Request link partner

to exit LPI

and send idles (used only when EEE is enabled).RESERVED

10: PHY SNR is marginal.
11: PHY SNR is good.

Both the status threshold and condition for generating this status are implementation dependent.

tx_boundary

This variable is set to TRUE whenever the transmit data stream reaches the start of a PHY frame TDD burst and a dummy OAM symbol is not transmitted per 149.3.9.2.1 during normal power operation in the data mode, or at the start of a transmit refresh cycle during Low Power Idle operation. This variable is set to FALSE at other times.

Values:

FALSE: Transmit stream is not at a boundary end.
TRUE: Transmit stream is at a boundary end.

tx_oam_field<9:0>

Ten-bit BASE-T1 OAM symbol inserted into a transmitted Reed-Solomon frameTDD burst during normal power operation in the data mode, or into a transmitted refresh cycle during Low Power Idle operation.

tx_oam<15 to 0><9:0>

Raw 16-symbol OAM frame transmitted from the PHY.

tx_lp_ready

Indicates whether the link partner is ready to receive the next BASE-T1 OAM message from the PHY. If ready, then the PHY will load the next BASE-T1 OAM message from the registers and begin transmitting them.

Values:

0: not ready
1: ready

tx_toggle

The toggle bit value being sent in the current BASE-T1 OAM frame transmitted by the PHY.

Values:

The value can be 0 or 1.

149.3.9.4.4 Counters

rx_cnt

A count of received OAM frame symbols.

Values:

The value can be any integer from 0 to 16, inclusive.

tx_cnt

OAM frame transmit symbol count.

Values:

The value can be any integer from 0 to 16, inclusive.

tx_rec

A count of received RS-FEC block errors, both correctable and uncorrectable.

Values:

The value can be any integer from 0 to 65 535, inclusive.

149.3.9.4.5 Functions

rs (14 OAM symbols)

This function outputs the 2 parity symbols as defined in 149.3.9.2.13.

If all 16 symbols of the OAM frame are embedded in tx_RSmessage<9:0> as described in 149.3.2.2.15 then this function can return any arbitrary value.

rs_correct (16 OAM symbols)

This function outputs the 14 corrected data symbols as defined in 149.3.9.2.13 and sets/clears the rs_check variable when at least one of the 16 symbols of the OAM frame is embedded in a LPI refresh.

Otherwise, tThis function returns the 14 data symbols unmodified and sets rs_check to GOOD if none of the 16 RS-FEC(360, 326) frames that carried any bit(s) of the 16 OAM symbols are uncorrectable.

149.3.9.4.6 State diagrams

The receive state diagram is shown in **Error! Reference source not found.**Figure 149–24 and the transmit state diagram is shown in **Error! Reference source not found.**Figure 149–

25.

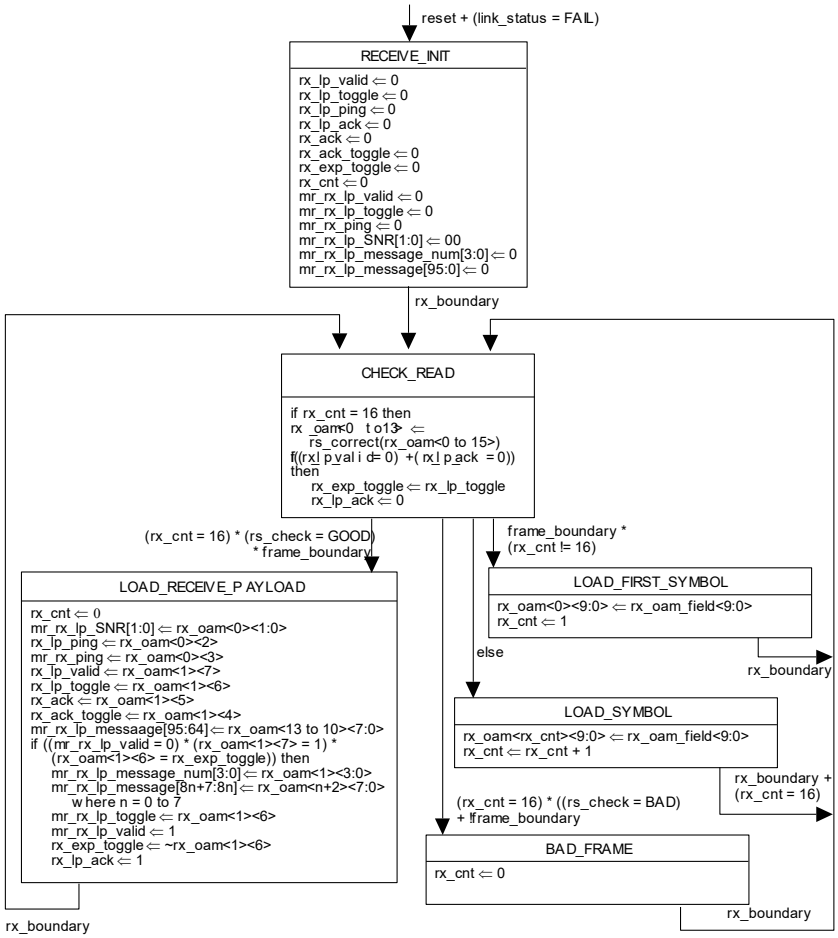

Figure 149–24—Receive state diagram

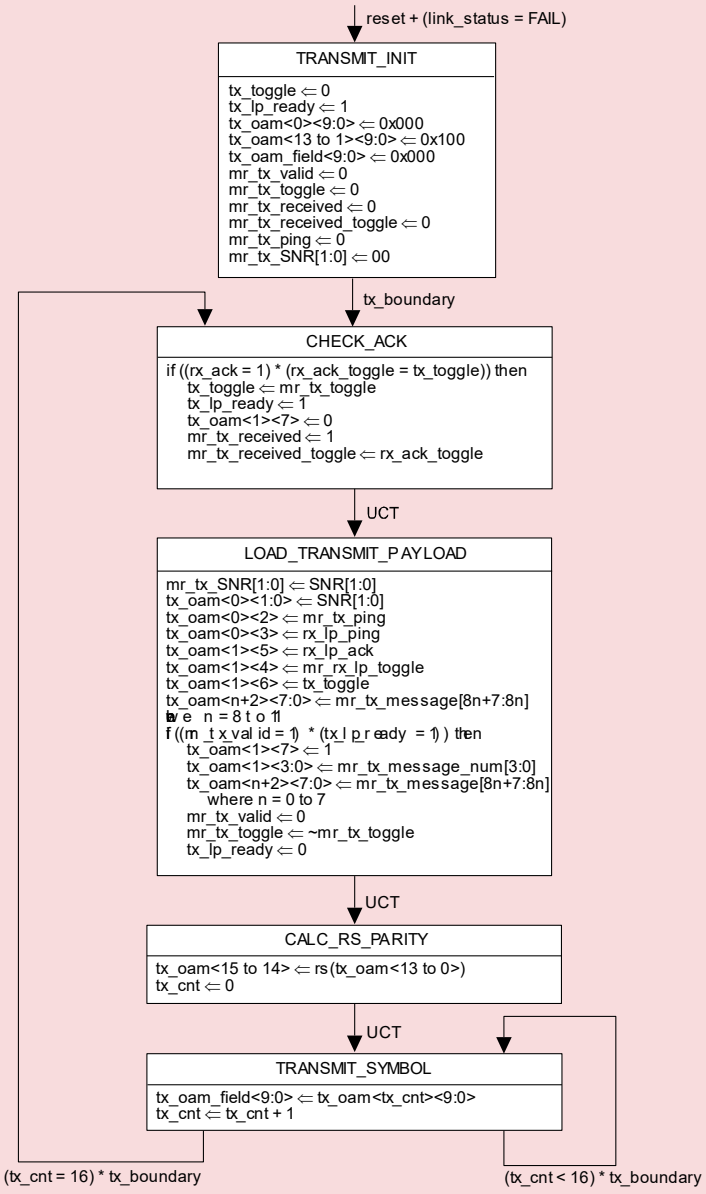

Figure 149–25—Transmit state diagram

[EDIT NOTES: Change CALC_RS_PARITY to INIT_TRANSMIT, Change "rs(tx_oam<13 to 0>" to 0x00000]

Commented [SM2]: Change CALC_RS_PARITY to INIT_TRANSMIT
Change "rs(tx_oam<13 to 0>" to 0x00000

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[Note to editor: The following table belongs in the Clause 192 PICS section and would point to clause 192 subclauses/figures. If not already, also add an additional PICS item for whether OAM is supported for clause 192 and it is O (optional) and supporting it makes the below OAM items mandatory]

149.11.4.2.8 OAM

Item	Feature	Subclause	Value/Comment	Status	Support
OAM1	State diagram behavior	Detailed functions and state diagrams~~149.3.9.4~~	Conforms to **Error! Reference source not found.**~~Figure 149–24~~ and **Error! Reference source not found.**~~Figure 149–25~~	OAM:M	Yes [ ] N/A [ ]
OAM2	When the PCS frame is operating in ~~interleaved mode of 2x or 4x~~HS_TX mode, the first first bit of the first OAM symbol (OAM<0>) shall be inserted in the first RS frame in the first superframe of the TDD burst and one subsequent bit of OAM<0> inserted into each of the next 9 RS-FEC frames so that one OAM symbol is carried in each TDD burst ~~so that the full OAM frame can packed into 8 superframes in the 2x interleaved mode, and into 4 superframes in the 4x interleaved mode~~. When the PCS frame is operating in LS_TX mode, the first symbol (OAM<0>) shall be inserted in the first 10 bits of the OAM field of the RS frame so that one OAM symbols is carried in each TDD burst.	MultiGBASE-A OAM frame structure~~149.3.9.2.1~~		OAM:M	Yes [ ] N/A [ ]
~~OAM3~~	~~Partially transmitted OAM frame~~	~~149.3.9.2.1~~	~~Described in 149.3.9.2.1~~	OAM:M	Yes [ ] N/A [ ]
OAM4	When OAM is not implemented	MultiGBASE-A OAM frame structure~~149.3.9.2.1~~	10-bit OAM field shall be set to all 0's	OAM:M	Yes [ ] N/A [ ]
OAM5	OAM frame data	OAM frame data~~149.3.9.2.2~~	Reserved fields shall be set to 0	OAM:M	Yes [ ] N/A [ ]
~~OAM6~~	~~OAM frame data symbol encoding~~	~~149.3.9.2.13~~	~~Using Reed-Solomon code (16,14)~~	OAM:~~M~~ O	Yes [ ] N/A [ ]

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OAM7	Parity calculation	149.3.9.2.13	Same result as the shift register implementation shown in Figure 149–23	OAM6: M	Yes [ ] N/A [ ]
OAM8	OAM Reed-Solomon shift register	149.3.9.2.13	Initialized to zero	OAM6: M	Yes [ ] N/A [ ]
OAM9	BASE-T1 OAM Frame acceptance criteria	MultiGBASE-T1 OAM frame acceptance criteria149.3.9.2.14	Described in MultiGBASE-T1 OAM frame acceptance criteria149.3.9.2.14	OAM:M	Yes [ ] N/A [ ]
OAM10	If a PHY is already in LPI mode and receives SNR<1:0> set to 01 by its link partner.	149.3.9.2.15	Immediately exit LPI	EEE*OAM:M	Yes [ ] N/A [ ]
OAM11	mr_tx_received	Variables149.3.9.4.3	Clear on read	OAM:M	Yes [ ] N/A [ ]

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