**45.2.3.48 1000BASE-H OAM transmit registers (Registers 3.500 through 3.508)**

These registers are used to provide an OAM channel between 1000BASE-H link partners. The OAM message is part of the physical header data (PHD) defined for 1000BASE-H (see table 114-2).

The transmit registers are used to compose an OAM message prior to transmission to the link partner. Register 3.500 provides control, status, message identification and message data information. Eight additional registers hold the rest of the OAM message data.

**Table 45-120- 1000BASE-H OAM transmit register bit definitions**

|  |  |  |  |
| --- | --- | --- | --- |
| **Bit(s)** | **Name** | **Description** | **R/Wa** |
| 3.500.15 | TXO\_REQ | Transmission request. It is set to one by the Management Entity to request the transmission of a new OAM Message. It shall be set to zero by the local PHY to indicate that the message has been accepted for transmission. | R/W |
| 3.500.14 | TXO\_PHYT | Transmit Message Phy Toggle bit. It corresponds to the toggle bit of the last message received by the remote PHY. | RO |
| 3.500.13 | TXO\_MERT | Transmit Message Management Entity Read Toggle bit. It corresponds to the toggle bit of the last message read by the Management Entity attached to the remote PHY. | RO |
| 3.500.12 | TXO\_MSGT | Transmit Message Toggle bit. This bit toggles with each new transmitted message and is used for message identification. | RO |
| 3.500.11:0 | TXO\_TYPE | Transmit Message data type information. Together with TXO\_DATA1 through TXO\_DATA8, it contains the payload of the OAM message. This information is not manipulated by the PHY and it is transparently transmitted to the link partner. | R/W |
| 3.501.15:0 | TXO\_DATA1 | Transmit Message 16-bit data word 1. | R/W |
| 3.502.15:0 | TXO\_DATA2 | Transmit Message 16-bit data word 2. | R/W |
| 3.503.15:0 | TXO\_DATA3 | Transmit Message 16-bit data word 3. | R/W |
| 3.504.15:0 | TXO\_DATA4 | Transmit Message 16-bit data word 4. | R/W |
| 3.505.15:0 | TXO\_DATA5 | Transmit Message 16-bit data word 5. | R/W |
| 3.506.15:0 | TXO\_DATA6 | Transmit Message 16-bit data word 6. | R/W |
| 3.507.15:0 | TXO\_DATA7 | Transmit Message 16-bit data word 7. | R/W |
| 3.508.15:0 | TXO\_DATA8 | Transmit Message 16-bit data word 8. | R/W |

aR/W=Read/Write, RO=Read Only

**45.2.3.48.1 TXO\_REQ (3.500.15)**

This bit is set to one by the Management Entity to request the transmission of the OAM message written to registers 3.500 through 3.508. It shall be set to zero by the local PHY to indicate that the message has been accepted for transmission, and that the registers are free to accept a new message.

**45.2.3.48.2 TXO\_PHYT (3.500.14)**

The local PHY shall indicate in this bit the TXO\_MSGT bit of the last message received by the remote PHY.

**45.2.3.48.3 TXO\_MERT (3.500.13)**

The local PHY shall indicate in this bit the TXO\_MSGT bit of the last message read by the Management Entity attached to the remote PHY.

**45.2.3.48.4 TXO\_MSGT (3.500.12)**

This bit is used for message identification; it shall contain the toggle bit of the last message accepted by the local PHY for transmission. It shall be toggled by the local PHY when it accepts a new message for transmission (simultaneously with the falling of bit TXO\_REQ).

Together with bits TXO\_REQ, TXO\_PHYT and TXO\_MERT, this bit indicates the status of the OAM transmission channel. There can be up-to three outstanding messages in the transmission channel: message written in the OAM transmission registers that is waiting for transmission, the message being currently transmitted by the local PHY, and the message available in the OAM reception registers of the remote PHY which is waiting for processing of the remote Management Entity.

Table 45-121 shows all the possible values of the four control bits, and the corresponding status of the three possible outstanding OAM messages. The control bits can be either 0 or 1, the symbol ~ denotes logical not operator. Message K is the message currently being transmitted by the local PHY to the remote PHY, its associated toggle bit takes value ‘a’ as indicated by bit TXO\_MSGT. Correspondingly, message K-1 denotes the previous message that was transmitted by the local PHY to the remote PHY. Its associated toggle bit takes value ‘~a’. Finally message K+1 corresponds to the OAM message being composed or yet to be requested for transmission by the local Management Entity. Its associated toggle bit will take value ‘~a’.

**Table 45-121-List of all possible 1000BASE-H OAM message status**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| TXO\_REQ | TXO\_PHYT | TXO\_MERT | TXO\_MSGT | Message K+1 Status | Message K Status | Message K-1 Status |
| 0 | a | a | a | Not written by local ME | Sent by local PHYACK by remote PHYACK by remote ME | Sent by local PHYACK by remote PHYACK by remote ME |
| 0 | ~a | ~a | a | Not written by local ME | Sent by local PHYNo ACK by remote PHYNo ACK by remote ME | Sent by local PHYACK by remote PHYACK by remote ME |
| 0 | a | ~a | a | Not written by local ME | Sent by local PHYACK by remote PHYNo ACK by remote ME | Sent by local PHY ACK by remote PHYACK by remote ME |
| 0 | ~a | a | a | Not written by local ME | Sent by local PHYNo ACK by remote PHYNo ACK by remote ME | Sent by local PHY ACK by remote PHYNo ACK by remote ME |
| 1 | a | a | a | Written by local MEPending transmission by local PHY | Sent by local PHY ACK by remote PHYACK by remote ME | Sent by local PHY ACK by remote PHYACK by remote ME |
| 1 | ~a | ~a | a | Written by local MEPending transmission by local PHY | Sent by local PHYNo ACK by remote PHYNo ACK by remote ME | Sent by local PHY ACK by remote PHYACK by remote ME |
| 1 | a | ~a | a | Written by local MEPending transmission by local PHY | Sent by local PHYACK by remote PHYNo ACK by remote ME | Sent by local PHY ACK by remote PHYACK by remote ME |
| 1 | ~a | a | a | Written by local MEPending transmission by local PHY | Sent by local PHYNo ACK by remote PHYNo ACK by remote ME | Sent by local PHYACK by remote PHYNo ACK by remote ME |

**45.2.3.48.5 TXO\_TYPE (3.500.11:0)**

These bits contain the data type of the OAM message that will be transmitted by the local PHY. These bits are not manipulated in any way by the local or remote PHY and together with the TXO\_DATAx bits carry the OAM message payload.

**45.2.3.48.6 TXO\_DATAx (Registers 3.501 through 3.508)**

These registers contain the 128 data bits of the OAM message that will be transmitted by the local PHY.

**45.2.3.49 1000BASE-H OAM receive registers (Registers 3.509 through 3.517)**

These registers are used to provide an OAM channel between 1000BASE-H link partners. The OAM message is part of the physical header data defined for 1000BASE-H (see table 114-2).

The receive registers hold the OAM messages received from the link partner. Register 3.509 provides status information, message identification and message data information. Eight additional registers hold the rest of the received OAM message data.

**Table 45-120- 1000BASE-H OAM reception register bit definitions**

|  |  |  |  |
| --- | --- | --- | --- |
| **Bit(s)** | **Name** | **Description** | **R/Wa** |
| 3.509.15 | RXO\_VAL | Reception valid. The PHY sets this bit to one to indicate that a new message has arrived and it is ready for processing. | RO |
| 3.509.14:13 | Reserved | Ignore on read. | RO |
| 3.509.12 | RXO\_MSGT | Receive Message Toggle bit. This bit toggles with each new received message and is used for message identification. | RO |
| 3.509.11:0 | RXO\_TYPE | Receive Message data type information. Together with RXO\_DATA1 through RXO\_DATA8, it contains the payload of the OAM message. | RO |
| 3.510.15:0 | RXO\_DATA1 | Receive Message 16-bit data word 1. | RO |
| 3.511.15:0 | RXO\_DATA2 | Receive Message 16-bit data word 2. | RO |
| 3.512.15:0 | RXO\_DATA3 | Receive Message 16-bit data word 3. | RO |
| 3.513.15:0 | RXO\_DATA4 | Receive Message 16-bit data word 4. | RO |
| 3.514.15:0 | RXO\_DATA5 | Receive Message 16-bit data word 5. | RO |
| 3.515.15:0 | RXO\_DATA6 | Receive Message 16-bit data word 6. | RO |
| 3.516.15:0 | RXO\_DATA7 | Receive Message 16-bit data word 7. | RO |
| 3.517.15:0 | RXO\_DATA8 | Receive Message 16-bit data word 8. | RO |

aR/W = RO=Read Only

**45.2.3.49.1 RXO\_VAL (3.509.15)**

The local PHY shall set this bit to one to indicate the reception of a new OAM message. It shall be set to zero when the message is processed by the Management Entity. The PHY shall not update the reception message registers with a new message until the previous message is processed by the Management Entity.

The Management Entity signals that it has finished processing the message by first reading register 3.509 having RXO\_VAL bit set to one, and then reading register 3.517. It is not required that the two accesses are contiguous; the Management Entity can access any other management register in between.

**45.2.3.49.2 RXO\_MSGT (3.509.12)**

This bit contains the toggle identifier of the received message. It shall toggle with every new received message.

**45.2.3.49.3 RXO\_TYPE (3.509.11:0)**

These bits contain the data type of the OAM message. These bits are not manipulated in any way by the PHY, and together with the RXO\_DATAx bits carry the received OAM message payload.

**45.2.3.49.4 RXO\_DATAx (registers 3.510 to 3.517)**

These registers contain the 128 data bits of the received OAM message.

**114.4 OAM Channel**

The optional OAM (Operations, Administration and Management) channel provides a mechanism to reliably exchange messages between Management Entity peers connected to link partners. The OAM message exchange does not impact the normal data exchange. It is also not affected by EEE operation.

The format of OAM messages is not specified in this standard. OAM message exchange occurs in the Physical Coding Sublayer (PCS), as part of the Physical Header Data (PHD).

The OAM channel utilizes OAM transmit and receive registers accessible via the MDIO as well as capabilities specified in the following channel descriptions. All MDIO accessible registers are specified in clauses 45.2.3.39 and 45.2.3.49.

The OAM channel uses several control bits (MSGT, MERT, PHYT) for message identification, message delivery notification and for flow control.

**114.4.1 OAM message transmission protocol**

When the Management Entity connected to the local PHY needs to transmit a new message it shall proceed as follows:

Step 1: Wait until TXO\_REQ bit of register 3.500 is zero, which indicates that the OAM transmit registers are free and that a new OAM message can be written.

Step 2: Write the 128 user data bits of the OAM message into register 3.501 through 3.508.

Step 3: Write the OAM message data type to TXO\_TYPE bits of register 3.500, setting bit TXO\_REQ to one at the same time to request the transmission of the new message.

When the local PHY accepts the message for transmission it shall notify it to the local Management Entity by setting to zero bit TXO\_REQ of register 3.500. Simultaneously it shall also perform the following operations:

* It shall toggle bit TXO\_MSGT bit of 3.500 register, and copy the new toggled value to PHD.OAM.MSGT field of the PHD.
* It shall copy the rest of the message to the PHD. Bits TXO\_TYPE of register 3.500 shall be copied to PHD.OAM.TYPE field of the PHD. Contents of registers 3.501 through 3.508 shall be copied to PHD.OAM.DATA1 through PHD.OAM.DATA8 fields of the PHD.

The local PHY shall not accept a new message for transmission until the previous OAM message has been accepted by the remote PHY. This happens when PHD.OAM.PHYT field of the last correctly received PHD is equal to PHD.OAM.MERT field of the PHD being transmitted by the local PHY.

Upon PHY reset, all the fields in the PHD dedicated to OAM channel implementation and all the bits in the MDIO transmit registers shall be set to 0.

The fields PHD.OAM.MSGT, PHD.OAM.TYPE and PHD.OAM.DATAx of the PHD shall always maintain the values corresponding to the last message accepted by the local PHY for transmission, or the reset value if either OAM is not enabled or no message has been accepted for transmission since the last PHY reset.

**114.4.2 OAM message reception protocol**

When the local PHY receives a new message on a correctly received PHD and the OAM receive registers are free, it shall copy the content of the new message to the OAM receive registers. It shall also perform the following operations:

* It shall set to one RXO\_VAL bit of register 3.509 to indicate the presence of a new message in the OAM receive registers to the Management Entity attached to the PHY.
* It shall copy the value of MSGT bit of the new receive OAM message to the PHD.OAM.PHYT field of the transmit PHD to indicate the remote PHY that the new message has been copied to the OAM receive registers and is available for processing by the Management Entity attached to the PHY.

When the Management Entity connected to the local PHY needs to read a new OAM message it shall proceed as follows:

Step 1: Wait until RXO\_VAL bit of register 3.509 is one, which indicates that a new OAM message is present on the OAM receive registers. When RXO\_VAL is one, the management Entity will capture the RXO\_MSGT and RXO\_TYPE bits of the new OAM message, as they are also stored in register 3.509.

Step 2: Read the rest of the message which is stored in registers 3.510 to 3.517. To guarantee the integrity of the OAM message register 3.517 should be the last register to be accessed by the Management Entity. This is because the read of register 3.517 triggers the read acknowledge of the Message to the remote partner, and the local PHY might update the OAM receive registers with a new OAM message right after register 3.517 is read.

When the local Management Entity processes the message by first reading register 3.509 having bit RXO\_VAL set to one, and then reading register 3.517, the local PHY shall notify it to the remote PHY by copying the MSGT bit of the message that has been read by the Management Entity to PHD.OAM.MERT field of the transmit PHD.

Upon PHY reset, fields PHD.OAM.PHYT, PHD.OAM.MERT and all the bits of the OAM receive registers shall be reset to zero.

The field PHD.OAM.PHYT of the PHD shall always maintain the value corresponding to the last message copied to the OAM receive registers, or zero when OAM is disabled or no message has been copied to OAM receive registers since last PHY reset.

The field PHD.OAM.MERT of the PHD shall always maintain the value corresponding to the last message processed by the Management Entity, or zero when OAM is disabled or no message has been processed by the Management Entity since last PHY reset.

**114.4.3 OAM channel state diagrams descriptions**

**114.4.3.1 OAM Tx control state**

The OAM transmit state diagram that governs PHY OAM transmission shall be implemented as shown in Figure 114–43.

Upon reset, disconnection of the PMA from the PMD or determination of an unreliable PHD communication link, OAM Tx registers are reset (OAMTX\_RESET state). Moreover, the transmitted PHD shall have all the fields reserved for OAM messages transmission set to 0.

Once the transmission and reception of PHD blocks is reliable (rcvr\_hdr\_lock = OK), and OAM channel is enabled, the local PHY waits for a new OAM message transmission request from the local Management Entity. Meanwhile, whenever a new PHD block is correctly received from the remote PHY, the local PHY shall update the value of TXO\_MERT bit of register 3.500 with that of the received PHD.OAM.MERT bit and TXO\_PHYT bit of register 3.500 with that of the received PHD.OAM.PHYT bit. By doing so, the local PHY notifies the attached Management Entity of the status of current and previous transmissions. This corresponds to OAMTX\_NEWMSG\_WAIT state.

As soon as the first OAM message transmission is requested by the local Management Entity (txr\_txreq = 1), the local PHY accept it, entering the OAMTX\_TRANSMIT state. This causes the content of transmit registers 3.501 to 3.508 and the 12-bit TXO\_TYPE field of register 3.500 to be copied to the corresponding PHD.OAM.DATAx and PHD.OAM.TYPE fields of the transmitted PHD. Simultaneously, bit PHD.OAM.MSGT is toggled and copied to bit TXO\_MSGT of register 3.500, and bit TXO\_REQ of register 3.500 is cleared to zero. Thus, the local PHY indicates to the attached ME the MSGT assigned to the message and also that the OAM Tx registers are free to accept a new message.

From then on, the local PHY shall keep transmitting the same OAM message within the PHD until the remote PHY acknowledges its reception (OAMTX\_PHYT\_WAIT state). Simultaneously, whenever a new PHD block is correctly received from the remote PHY, the local PHY shall update the value of TXO\_PHYT and TXO\_MERT of register 3.500 with the value of fields PHD.OAM.PHYT and PHD.OAM.MERT of the received PHD. As soon as the OAM message that is being currently transmitted within the PHD is acknowledged by the remote PHY, the local PHY can accept a new OAM message for transmission. The transition from state OAMTX\_PHYT\_WAIT to state OAMTX\_NEWMSG\_WAIT occurs when the field PHD.OAM.PHYT of the received PHD takes the same value as that of the field PHD.OAM.MSGT of the transmitted PHD (rxphd\_phyt = txphd\_msgt).



Figure 114-43 : PHY OAM Tx control state diagram

The variables used in the state diagram of Figure 114–43 are defined as follows.

pma\_reset

Allows reset of all the PMA functions. It is set by the PMA reset. PMA reset function is intended to be executed whenever one of power on or reset from management entity conditions occurs. All state diagrams take the open-ended pma\_reset branch upon execution of PMA Reset.

Values: ON: reset is asserted

 OFF: reset is de-asserted

link\_control

Controls the connection of the PMA to the PMD. This control variable is foreseen for an eventual coexistence of the PHY with an autonegotiation sub-system.

Values: DISABLE: isolates the PMA from the PMD

 ENABLE: connects the PMA to the PMD (both transmitter and receiver)

oam\_cap

Controls the enable of OAM channel functionality. This variable is set to TRUE when PHD.CAP.OAM of both transmit and receive PHD is TRUE. Otherwise it is FALSE.

Values: TRUE: both local and remote PHY have OAM ability and OAM functionality is enabled in both PHYs.

FALSE: either local or remote PHY do not have OAM ability or it is disabled.

txr\_txreq

Value of TXO\_REQ bit of register 3.500. It indicates whether the local ME is requesting the transmission of a new OAM message.

Values: 0: there is no message transmission request from the local ME

1: the local ME has written a new message into the OAM transmit registers and is requesting the local PHY to transmit it

txr\_msgt

Value of TXO\_MSGT bit of register 3.500. This bit is updated in OAMTX\_TRANSMIT state to reflect the toggle bit of the message being sent by the local PHY.

Values: It alternates between values 0 and 1

txr\_phyt

Value of TXO\_PHYT bit of register 3.500. This bit is updated in OAMTX\_TRANSMIT state to reflect the identifier of the last message that has been acknowledged by the remote PHY.

Values: It alternates between values 0 and 1

txr\_mert

Value of TXO\_MERT bit of register 3.500. This bit is updated in OAMTX\_TRANSMIT state to reflect the identifier of the last message that has been acknowledged by the remote ME.

Values: It alternates between values 0 and 1

txr\_oamudat

OAM message data written in OAM transmit registers 3.501 to 3.508 and to field TXO\_TYPE of register 3.500.

Values: Any value

txphd\_msgt

Identifier of the message being transmitted by the local PHY. It corresponds to field PHD.OAM.MSGT of the PHD.

Values: It alternates between values 0 and 1

txphd\_oamudat

Content of the PHD fields PHD.OAM.TYPE and PHD.OAM.DATAx being transmitted by the local PHY.

Values: Any value

rxphd\_phyt

Content of the field PHD.OAM.PHYT of the last PHD that has been correctly received by the local PHY.

Values: It alternates between values 0 and 1

rxphd\_mert

Content of the field PHD.OAM.MERT of the last PHD that has been correctly received by the local PHY.

Values: It alternates between values 0 and 1

new\_rxphd\_event

Variable set by the PCS receiver to indicate the arrival of a new PHD block from the link partner.

Values: TRUE: indicates the event of a new PHD received from link partner. The value TRUE extends one receive symbol period

 FALSE: indicates no new PHD was received

rcvr\_hdr\_lock

Variable set by the PMA receiver to indicate whether reliable transmission (i.e. reliable reception by the link partner) and reception of PHD are detected

Values: OK: PHD transmission and reception are reliable

 NOT\_OK: PHD transmission or reception is unreliable

hdr\_crc16\_status

Result of the CRC16 evaluation for a received PHD from the link partner; this variable is assigned for each received PHD block.

Values: OK: the received PHD block is correct by CRC16 verification

 NOT\_OK: the received PHD block is not correct determined by CRC16

 verification

**114.4.3.2 OAM Rx control state**

The OAM receive state diagram that governs PHY OAM reception shall be implemented as is shown in Figure 114–44.

Upon reset, disconnection of the PMA from the PMD or determination of an unreliable PHD, OAM receive registers are reset (OAMRX\_RESET state). Moreover, bits PHD.OAM.MERT and PHD.OAM.PHYT shall also be set to zero.

Once the transmission and reception of PHD blocks is reliable (rcvr\_hdr\_lock = OK), the local PHY waits until the field PHD.OAM.MSGT of a correctly received PHD block takes a value that is different from that of the RXO\_MSGT bit of register 3.509. This indicates that a new OAM message has been received from the remote PHY. As soon as this event occurs, transition from state OAMRX\_NEWMSG\_WAIT to state OAMRX\_RXR\_UPDT takes place.

In the state OAMRX\_RXR\_UPDT, the content of the fields PHD.OAM.DATAx and PHD.OAM.TYPE of the received PHD are and stored in OAM receive registers 3.510 to 3.517 and field RXO\_TYPE of register 3.509. Simultaneously bit RXO\_VAL of register 3.509 is set to one, and field RXO\_MSGT of register 3.509 is updated with value of field PHD.OAM.MSGT of the received PHD. Additionally, the local PHY shall notify the remote PHY of the reception of the message by setting the field PHD.OAM.PHYT of the transmit PHD to the value of PHD.OAM.MSGT of the received PHD (txphd\_phyt <= rxphd\_msgt).

OAMRX\_RXR\_UPDT state exits when register 3.509 is read (read\_OAMCTRL\_event = TRUE). The RXO\_VAL bit being equal to one indicates to the local Management Entity that a new message is available in the OAM receive registers. The local PHY locks these registers (transition to OAMRX\_RXR\_LOCK state) until register 3.517 is read (read\_OAMDATA8\_event = TRUE). This event is the acknowledgment by the local Management Entity that the OAM message has been

successfully received. Thus, state OAMRX\_MERT\_UPDT sets bit RXO\_VAL of register 3.509 to zero indicating that no valid message is stored in the OAM receive registers. Moreover, the local PHY shall notify the reception of the message by the local management entity by assigning field PHD.OAM.MERT of the transmit PHD to the value of RXO\_MSGT bit of register 3.509 (txphd\_mert <= rxr\_msgt).

The local PHY then waits for a new message to be received (OAMRX\_NEWMSG\_WAIT).



Figure 114-44 : PHY OAM Rx control state diagram

The variables used in the state diagram Figure 114–44 that have not been previously introduced are as follows.

rxr\_rxval

Value of RXO\_VAL bit of register 3.509. This bit indicates the presence of a valid message in the OAM receive registers.

Values: 1: there is a valid message in the receive registers, which is pending processing by the local Management Entity

 0: there is no valid message in the receive registers

rxr\_msgt

Value of RXO\_MSGT bit of register 3.509. This bit is the toggle bit identifier of the message contained in the OAM receive registers.

Values: It alternates between values 0 and 1

rxr\_oamudat

The received OAM message data. It is the content of registers 3.510 to 3.517, and field RXO\_TYPE of register 3.509.

Values: Any value

txphd\_phyt

Value of the PHD field PHD.OAM.PHYT being transmitted by the local PHY. It indicates to the remote PHY the toggle bit identifier of the last valid message written to the Rx registers.

Values: It alternates between values 0 and 1

txphd\_mert

Content of the PHD field PHD.OAM.MERT being transmitted by the local PHY. It informs the remote PHY the toggle bit identifier of the last message that has been received by the local ME.

rxphd\_msgt

Value of the PHD field PHD.OAM.MSGT of the last valid received PHD. It contains the toggle bit identifier of the OAM message carried in that PHD.

Values: It alternates between values 0 and 1

rxphd\_oamudat

Content of fields PHD.OAM.TYPE and PHD.OAM.DATAx of the last PHD correctly received by the local PHY. It is the payload of the OAM message.

Values: Any value

read\_RXOAM\_CTRL\_event

Event to indicate that the OAM receive register 3.509 has been read.

Values: TRUE: register 3.509 has been read

 FALSE: register 3.509 has not been read

read\_RXOAM\_DATA8\_event

Event to indicate that the OAM receive register 3.517 has been read.

Values: TRUE: register 3.517 has been read

 FALSE: register 3.517 has not been read