rcvr_thp_lock

Variable set by the THP REQ state diagram (see 114.3.2.2.2) to indicate whether the Tomlinson-Harashima precoding is initialized, therefore the PHY is receiving payload data sub-blocks TH precoded with the coefficients that were requested by the THP REQ state diagram.

Values: OK: THP is initialized; payload data are received TH precoded
NOT_OK: THP is not initialized

rx_gmii_enable

Variable set by the PHY RX control state diagram to connect or disconnect the 64B/65B decoder to the GMII RX; this connection is only enabled when a bidirectional link is established

Values: TRUE: 64B/65B decoder is connected to GMII RX
FALSE: 64B/65B decoder is not connected to GMII RX

tx_gmii_enable

Variable set by the PHY TX control state diagram to connect or disconnect the 64B/65B encoder to the GMII TX; this connection is only enabled when bidirectional link is established

Values: TRUE: 64B/65B encoder is connected to GMII TX
FALSE: 64B/65B encoder is not connected to GMII TX (normal interframe are encoded in transmitted PDBs)

tx_enable

Variable set by the PHY TX control state diagram to enable the PCS transmit function

Values: TRUE: PCS transmitter is enabled
FALSE: PCS transmitter is disabled

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

hdr_fail_count

Variable used as counter of the reception of contiguous erroneous PHD blocks.

114.3.2.2 Adaptive THP protocol description

Tomlinson-Harashima precoding (THP) is used as the channel equalization technique to compensate the inter-symbol interference (ISI).

In general, harmonic distortion affecting the received signal may exist due to the non-linear response of the photonics integrated into the PMD. The PCS receiver may implement non-linear channel response compensation in addition to the THP implemented in the PCS transmitter. For estimation of the filters in charge of linearizing the channel, the PHY may use the received pilot S2. Channel linearization is up to the implementer and is to be fully implemented in the PHY receiver. It does not require coordination with the link partner transmission.

The receiver estimates the coefficients that are used by the remote PHY transmitter to precode the payload data sub-blocks (coefficients b(i) in 114.2.4.5). This estimation can use the received pilot S2 and is to be performed continuously in order to track the channel response variations.

The local receiver assigns a set identifier (integer number higher than 0 and lower than 4) to each new estimation to unambiguously identify it, and uses it to request the remote transmitter to apply a given set of coefficients for THP by using the field LOCPHD.RX.REQ.THP.SETID on transmitted PHD. The set of coefficients itself is sent to the link partner by using the field LOCPHD.RX.REQ.THP.COEF.

Once the local receiver has performed the request, it waits until the remote transmitter signals via the PHD field REMPHD.TX.NEXT.THP.SETID that payload data in the next Transmit Block is TH precoded with

the requested set of coefficients. From then on, the local receiver adapts its circuitry according to the THP coefficients used at the remote transmitter and is allowed to perform a new request for changing them.

A formal definition of the THP coefficients adaptation protocol is provided in the form of state diagrams in the following subclauses.

114.3.2.2.1 Adaptive THP TX state diagram

Figure 114–40 shows the state diagram that governs the adaptation of the coefficients of the filter used by the local PHY transmitter to precode payload data sub-blocks in response to the requests performed by the link partner.

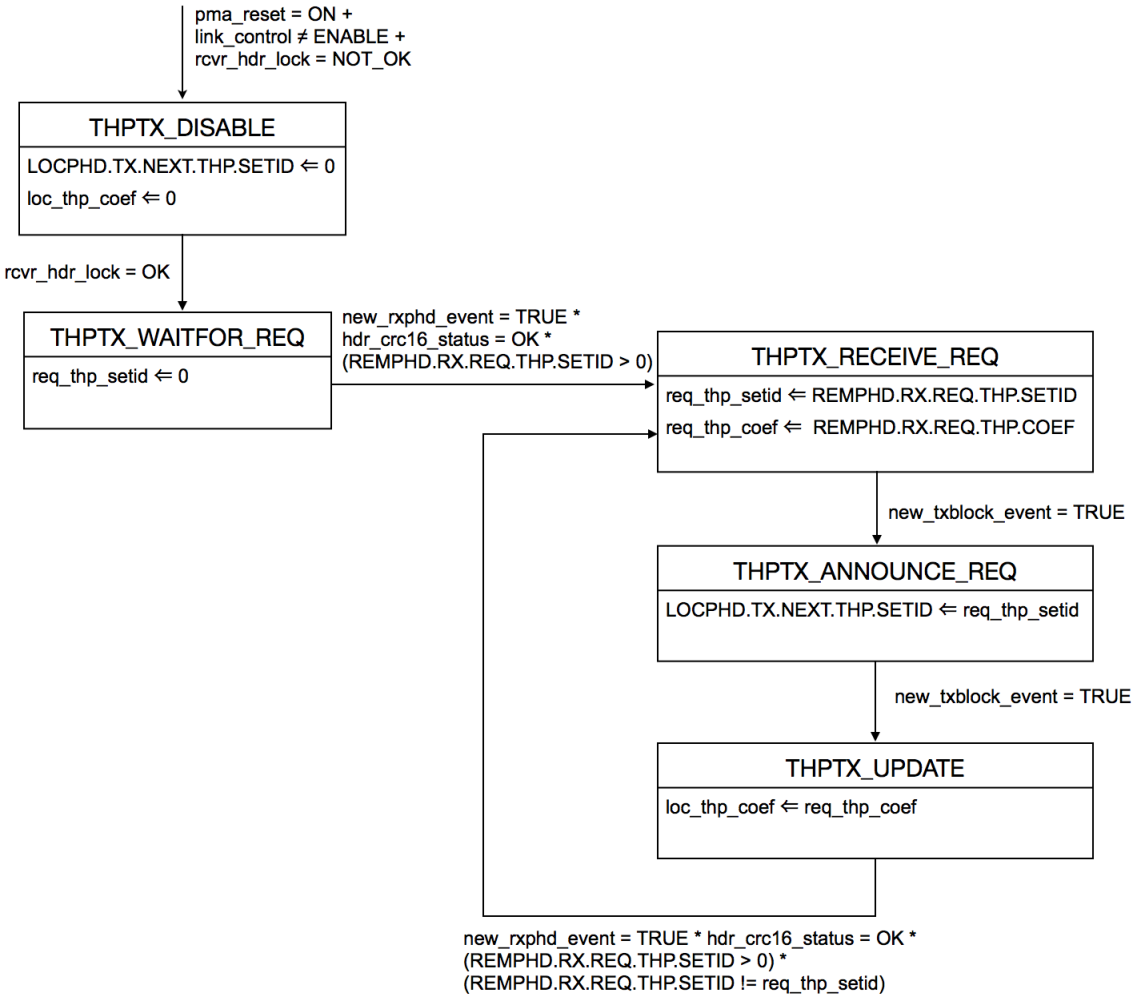

Figure 114–40—Adaptive THP TX state diagram

Upon reset, disconnection of the PCS from the PMD or unreliable PHD communication link, transmitted payload data is no longer TH precoded (THPTX_DISABLE state). This implies that THP coefficients are set to zero (loc_thp_coef ⇐ 0) and the field LOCPHD.TX.NEXT.THP.SETID on the transmitted PHD is assigned the value 0 to indicate to the remote PHY that THP is disabled.

Once the transmission and reception of PHD blocks are reliable (rcvr_hdr_lock = OK), the local PHY waits for a request to adapt its THP coefficients from the link partner (THPTX_WAITFOR_REQ state).

As soon as the value of the field REMPHD.RX.REQ.THP.SETID of a correctly received PHD block is higher than 0, which indicates a THP coefficients adaptation request from the remote partner, the local PHY stores the set identifier associated to the request (req_thp_setid ⇐ REMPHD.RX.REQ.THP.SETID) and the requested coefficients (req_thp_coef ⇐ REMPHD.RX.REQ.THP.COEF). This corresponds to the state THPTX_RECEIVE_REQ.

Triggered with the start of a new Transmit Block the state transitions to THPTX_ANNOUNCE_REQ where the local PHY announces that requested coefficients will be used (LOCPHD.TX.NEXT.THP.SETID ⇐ req_thp_setid).

After the announcement and triggered with the start of a new Transmit Block the state transitions to THPTX_UPDATE. From then on, payload data sub-blocks of all Transmit Blocks are TH precoded with the requested set of coefficients (loc_thp_coef ⇐ req_thp_coef) until a new request for changing THP coefficients is signaled from the link partner. This happens when the value of the field REMPHD.RX.REQ.THP.SETID of a correctly received PHD block is higher than 0 and different from the value of the variable req_thp_setid. At this moment, the new set of coefficients is to be stored, announced and applied as previously explained.

All the variables used in the state diagram that have not been previously introduced are defined in 114.3.2.2.3.

114.3.2.2.2 Adaptive THP REQ state diagram

Figure 114–41 shows the state diagram that manages the requests to the remote PHY for adapting THP coefficients.

Upon reset, disconnection of the PCS from the PMD or unreliable PHD communication link, the local PHY is not able to receive TH precoded payload data sub-blocks (rcvr_thp_lock ⇐ NOT_OK). This is signaled to the remote PHY by setting to 0 the LOCPHD.RX.REQ.THP.SETID field on the transmitted PHD.

Once the transmission and reception of PHD blocks are reliable (rcvr_hdr_lock = OK) and the first set of THP coefficients are ready from the estimator (new_thp_coef_event = TRUE) the state transitions to THPREQ_STORE.

In this state, the newly estimated coefficients are stored (thp_coef ⇐ est_thp_coef) and assigned a set identifier. The set identifier is calculated based on the identifier previously requested as thp_setid ⇐ mod(thp_setid, 3) + 1, with modulo operator as defined in Equation (114–3).

The request for changing the set of THP coefficients is performed in the next available Transmit Block by means of the PHD fields intended for this purpose (transition to THPREQ_REQUEST state). More precisely, the LOCPHD.RX.REQ.THP.SETID field indicates the associated set identifier, whereas the set of coefficients itself is transmitted by using the field LOCPHD.RX.REQ.THP.COEF.

Then, the local PHY receiver waits for the link partner to signal that THP request has been already handled, which means that link partner will start using the requested coefficients for TH precoding on the next Transmit Block. Once this event occurs (new_rxphd_event = TRUE and hdr_crc16_status = OK and REMPHD.TX.NEXT.THP.SETID = thp_setid) the state transitions to THPREQ_WAITFOR_RX.

In this state, the PHY receiver waits for the next Transmit Block received from the link partner. Once this event occurs, the state transitions to THPREQ_UPDATE, where value OK is assigned to the state variable rcvr_thp_lock, indicating the payload data sub-blocks are received with TH precoding. In

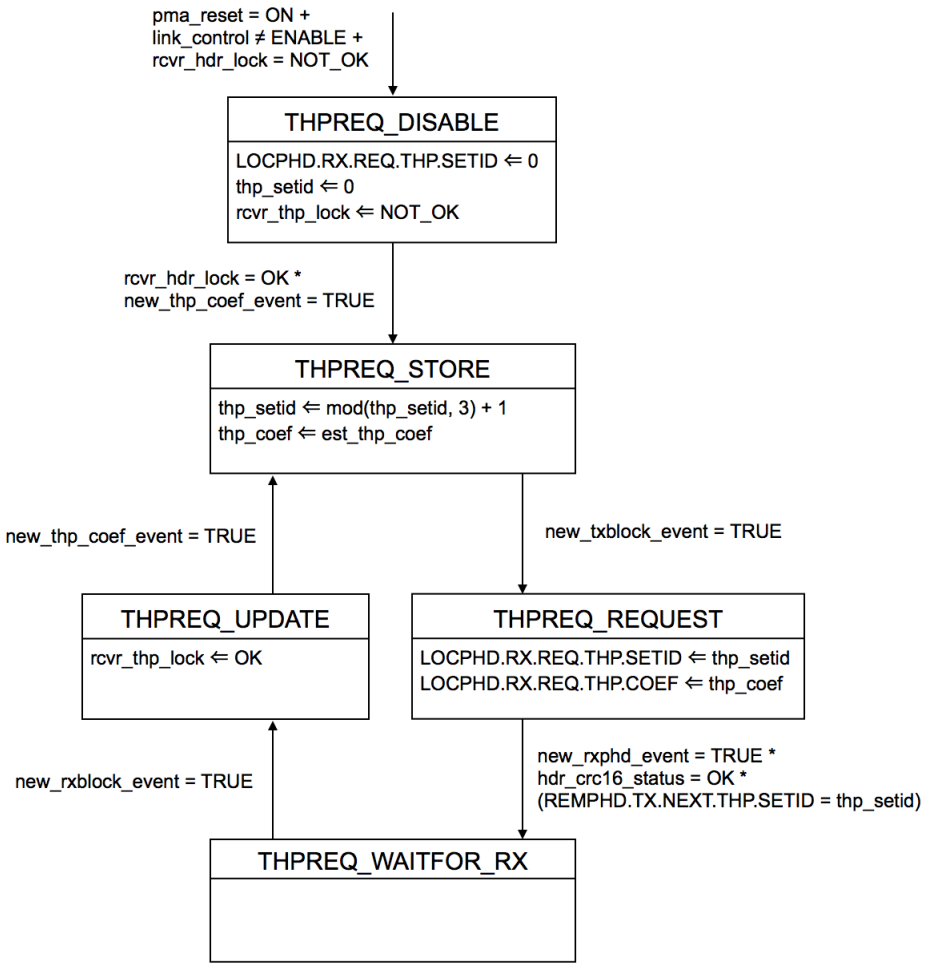

Figure 114–41—Adaptive THP REQ state diagram

THPREQ_UPDATE state the PHY receiver also adapts its circuitry to match the THP coefficients used at the remote transmitter.

Whenever a new set of THP coefficients from estimator is available, it shall be stored and requested as explained above. The local PHY receiver is not allowed to make a new THP request until the previous THP request has been handled by the link partner, even if a new set of coefficients is available from the estimator.

All the variables used in the state diagram that have not been previously introduced are defined in 114.3.2.2.3.

114.3.2.2.3 Adaptive THP state variables

new_txblock_event

Variable set by PHY transmitter to indicate the encoding of a new Transmit Block.

Values: TRUE: indicates the event of a new Transmit Block transmission start. The value TRUE extends one transmit symbol period and it is synchronous with the first zero symbol of the pilot S1 sub-block of each Transmit Block
FALSE: indicates not the start of a new Transmit Block

new_rxblock_event

Variable set by PHY receiver to indicate the reception of a new Transmit Block.

Values: TRUE: indicates the event of a new Transmit Block reception start. The value TRUE extends one receive symbol period and it is synchronous with the the reception of the first zero symbol of the pilot S1 sub-block of each Transmit Block
FALSE: indicates not the start of a new Transmit Block

loc_thp_coef

Variable set by the adaptive THP TX state diagram that contains the local coefficients used by the PHY for TH precoding of payload data sub-blocks. loc_thp_coef is a set of 9 real numbers representing the coefficients of the feedback filter of THP (b(i) in 114.2.4.5).

Values: real numbers that take value in the interval [-2, 2)

req_thp_coef

Variable set by the adaptive THP TX state diagram when a correct PHD is received. This variable holds the coefficients requested by the link partner to be used for TH precoding of the payload data sub-blocks. req_thp_coef is a set of 9 real numbers in fixed-point format (see 114.3.3) as received via PHD in the field REMPHD.RX.REQ.THP.SETID.

Values: real numbers that take values in the interval [-2, 2)

req_thp_setid

Variable set by the adaptive THP TX state diagram when a correct PHD is received. It is the set identifier assigned to the THP coefficients requested by the link partner.

Values: 0: no request to change the THP coefficients
1, 2, 3: requested set identifier

thp_setid

Variable set by the adaptive THP REQ state diagram to store the last THP set identifier requested to the link partner.

Values: 0: reset value
1, 2, 3: set identifier

thp_coef

Variable set by the adaptive THP REQ state diagram to store the last THP coefficients requested to the link partner. thp_coef is a set of 9 real numbers.

Values: real numbers that take value in the interval [-2, 2)

est_thp_coef

Variable set by the PHY receiver that contains the coefficients estimated to compensate inter-symbol interference by means of Tomlinson-Harashima Precoding. est_thp_coef is a set of 9 real numbers.

Values: real numbers that take value in the interval [-2, 2)

new_thp_coef_event

Variable set by the PHY receiver to indicate the result of a new THP estimation is available.

Values: TRUE: indicates a new set of THP coefficients is available. The value TRUE extends one receive symbol period. In general it is asynchronous to new_rxblock_event
FALSE: indicates no new set of THP coefficients is available

114.3.2.3 PHY quality monitor state diagram

The PHY quality monitor is in charge of determining the value of the variable loc_rcvr_status, which indicates whether the local PHY is able to provide reliable reception of payload data. This function may be based on an estimate of the noise variance at the MLCC decoder $E\left[n_d^2 \right]$, which expressed in logarithmic units shall be lower than a given threshold Σ in order to guarantee reliable local reception of payload data. Thus, if the condition $\log_2(E[n_d^2]) < \Sigma$ holds, the variable loc_rcvr_status is assigned the value OK.