replace the beginning of a payload data sub-block. Wake is implicit in the presence of normal 16-PAM Tomlinson-Harashima precoded signal at the beginning of a payload data sub-block.

114.5.3 1000BASE-RH PHY LPI mode receive operation

In the receive direction, entering LPI mode is triggered by the detection of a sequence of zero symbols instead of PAM/THP signal at the beginning of a data sub-block. When the local PHY receiver detects this event, it encodes “Assert LPI” on the GMII and disables some functionality to reduce power consumption.

NOTE -- “Assert LPI” can also be encoded on the GMII RX due to the reception of PDBs containing LPI signaling from the link partner (this is the case of LPI assertion on the GMII TX in the middle of a payload data sub-block transmission).

In LPI mode, the local PHY receiver shall use received pilot and physical header sub-blocks, which are sent periodically by the link partner, to update adaptive coefficients and timing circuits and to determine the value of loc_rcvr_status. Therefore, in LPI mode, the receiver shall also use the refresh signals to estimate the quality of decoding (i.e. link margin).

This quiet-refresh cycle continues until PAM Tomlinson-Harashima precoded signal at the beginning of a payload data sub-block slot is detected. The receive PHY exits LPI mode and returns to normal operation, sending the received payload to the GMII. The PCS decoding shall start aligned to the boundary of the first complete PDB received from the beginning of the payload data sub-block. At this moment, the local PHY begins to send normal-interframe encoding on the GMII, since this is the information received from the remote PHY and the link is ready to provide the nominal operational data rate.

114.5.4 1000BASE-RH PHY LPI mode timing parameters

Three key EEE parameters (T_s, T_q and T_r) are specified in Table 78–2 for a 1000BASE-H PHY.

The period of time that the PHY remains quiet before sending the refresh signal (pilot or physical header sub-blocks), denoted as T_q, corresponds to the transmission time of a payload data sub-block subtracting the time needed to transmit the sequences of zero symbols for quiet indication and for receiver preparation, which is given by

$$T_{payload}\ (\mu s) = (NCW * NSYM\_CW - NSYM\_ZERO) / F_s = (8*988 - 160)/325 = 23.83\ \mu s$$

where NCW is the number of FEC codewords transmitted per payload data sub-block, NSYM_CW is the number of symbols composing a FEC codeword, NSYM_ZERO is the total number zero value symbols summing up those for quiet indication and receiver preparation, and F_s is the symbol frequency in MHz.

The duration of the refresh signal, denoted as T_r, corresponds to the transmission time of a pilot or physical header sub-block plus the time for quiet indication and receiver preparation, which is given by

$$T_{pilot/PHS}\ (\mu s) = (\mathbf{NSYM} + NSYM\_ZERO) / F_s = (16 + 128 + 16 + 160)/325 = 0.985\ \mu s \quad (114–1)$$

where NSYM is the number of symbols composing a pilot or physical header sub-block.

Additional LPI timing parameters for 1000BASE-H are specified in Table 78–4. Note that 24.82 μs is the time needed to transmit a pilot or physical header sub-block and a payload data sub-block.

114.6 Interface to the PMD

The interface between the PCS and the PMD is defined in terms of signals for which no specific implementation is described.

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114.6.1 Signals transmitted to the PMD

Any signal transmitted to the PMD by the PCS transmitter can be expressed in a general form independent of the different parts that compose the periodic Transmit Block (see 114.2.1) as follows.

$$\begin{aligned} x(n) &= SF(n) \cdot F_M\left(a(n) + \sum_{i=0}^{N_b-1} x(n-i-1)b(i)\right) \\ &= SF(n) \cdot \left(a(n) + 2M \cdot m(n) + \sum_{i=0}^{N_b-1} x(n-i-1)b(i)\right) \end{aligned} \quad (114\text{–}2)$$

Where, $a(n)$ is an M-PAM modulation symbol that can take values from the set {-M + 1, -M+3, ... +M - 3, +M-1} to be transmitted at time instants $n \cdot T_s$, where T_s is the transmit symbol period ($T_s = 1/F_s = 1000/325$ ns), *SF(n)* is the power scaling factor specified for each part of the Transmit Block according to 114.2.1, *b(i)* are the coefficients of TH precoder specified in 114.2.4.5, and the nonlinear operation $F_M(\alpha) = mod(\alpha + M, 2M) - M$ corresponds to moving the signal $\alpha(n)$ to a reduced signal $\tilde{\alpha}(n) = \alpha(n) + 2M \cdot m(n)$ with the integer $m(n)$ chosen for each sample such that the output lies in the interval $-M \le \tilde{\alpha}(n) < M$, when THP is used.

When a pilot S1 sub-block or PHS_x sub-block is transmitted, $M = 2$ and $SF(n) = 255$. For transmission of an $S2_x$ sub-block, M = 256 and SF(n) = 1. For the zero symbol sequences that prefix and postfix each S1, S2 and PHS_x sub-block, $a(n) = 0$.

When data payload sub-blocks are transmitted, $M = 16$ and $SF(n) = 16$. Only for this part of the Transmit Block the coefficients $b(i)$ may take a value different to zero, when THP coefficients are negotiated with the link partner according to the protocols defined in 114.3.2.2.

For any part of the Transmit Block, the transmitter output signal $x(n)$ fits $-256 \le x(n) < 256$.

114.6.2 Signals received from PMD

Signals received from the PMD can be expressed as pulse-amplitude modulated signals that have been filtered by a non-linear channel and corrupted by noise as follows:

$$\begin{aligned} y(n) &= w_{o0} + \sum_{l_1=0}^{L} w_{o1}(l_1)x(n-l_1) + \sum_{l_1=0}^{L}\sum_{l_2=0}^{L} w_{o2}(l_1, l_2)x(n-l_1)x(n-l_2) + \ldots \\ &\ldots + \sum_{l_1=0}^{L}\sum_{l_1=0}^{L} \ldots \sum_{l_P=0}^{L} w_{oP}(l_1, l_2, \ldots l_P)x(n-l_1)x(n-l_2)\ldots x(n-l_P) + N(n) \end{aligned} \quad (114\text{–}3)$$

where the received signal $y(n)$ is sampled by the PCS receive function with the recovered clock, at the optimum phase and with a frequency equal to the transmit symbol clock Fs. $x(n)$ is the transmitted signal to the PMD from the PCS transmitter, $N(n)$ the additive noise from optical to electrical conversion, and w_{ox} are the kernels of a truncated Volterra series that represents the non-linear response of the communication channel.

The received signal considers the electrical-to-electrical communication channel composed of all the elements from the PCS transmitter to PCS receive function, including the electrical-to-optical conversion carried out by the PMD transmitter, the optical fiber and the optical-to-electrical conversion carried out by the PMD receive function.

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